AD-A136 329 PASSIVE SOLAR DESIGN PROCEDURES FOR NAVAL INSTALLATIONS 1/2
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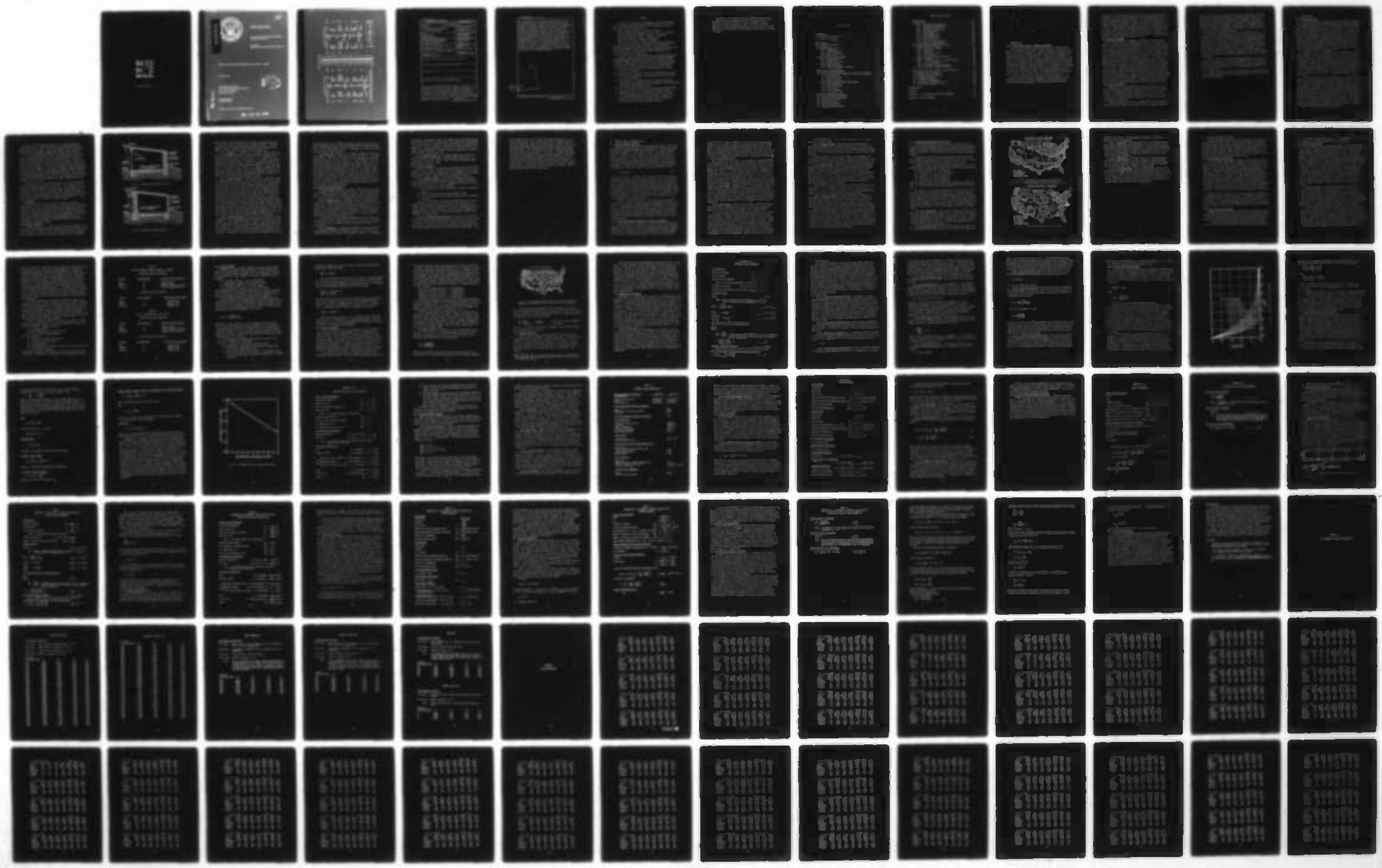
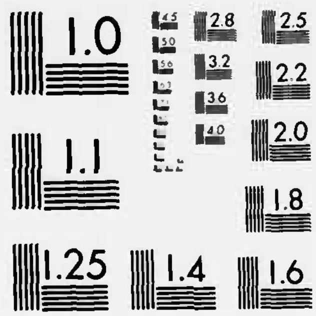
NCEL-CR-83.040 N68305-82-MP-20006

UNCLASSIFIED F/G 13/1 NL





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CR 83.040

NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVAL FACILITIES ENGINEERING COMMAND

PASSIVE SOLAR DESIGN PROCEDURES FOR NAVAL INSTALLATIONS

September 1983

An Investigation Conducted by
LOS ALAMOS NATIONAL LABORATORY
Solar Energy Group, MS K571
Los Alamos, NM 87545

N6830582MP20006
N6830582MP20010

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CR 83.040	2. GOVT ACCESSION NO. AD-A136	3. RECIPIENT'S CATALOG NUMBER 329
4. TITLE (and Subtitle) PASSIVE SOLAR DESIGN PROCEDURES FOR NAVAL INSTALLATIONS		5. TYPE OF REPORT & PERIOD COVERED Interim Contract Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William O. Wray Franz A. Biehl Claudia E. Kosiewicz		8. CONTRACT OR GRANT NUMBER(s) N6830582MP20006 N6830582MP20010
9. PERFORMING ORGANIZATION NAME AND ADDRESS LOS ALAMOS NATIONAL LABORATORY Solar Energy Group, MS K571 Los Alamos, NM 87545		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Z0371-01-551A Z0371-01-111A
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Civil Engineering Laboratory Port Hueneme, CA 93043		12. REPORT DATE September 1983
		13. NUMBER OF PAGES 108
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Facilities Engineering Command 200 Stovall Street Alexandria, VA 22332		15. SECURITY CLASS (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Solar, passive solar, passive design procedures

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The energy efficiency of buildings at Naval installations can be greatly improved through the use of passive solar heating strategies. These strategies may be applied to many existing buildings that are suitable for retrofit and are universally applicable to new construction. The purpose of this design procedure is to provide the tools required by professionals involved

in building design and/or evaluation who wish to improve the the energy efficiency of buildings by use of passive solar heating. Three types of tools are provided. First, a general discussion of the basic concepts and principles of passive solar heating is presented to familiarize the reader with this relatively new technology. Second, a set of guidelines are presented for use during schematic design that will enable the user to quickly define a building that will perform in a cost-effective manner at the intended building site. Finally, a quantitative design-analysis procedure is presented that provides the user with an accurate estimate of the auxiliary heating requirements of a given passive solar design. This procedure is presented that provides the user with an accurate estimate of the auxiliary heating requirements of a given passive solar design. This procedure may be used to refine or fine tune a preliminary design based on the schematic-design guidelines or may be used during proposal evaluation to compare the merits of various candidate designs.

PREFACE

This report is an extension and refinement of an earlier five-volume set of publications entitled "Design Calculation Procedure for Passive Solar Houses at Navy Installations in

Regions with Cold Climates - Volume I," CR 82.002,

East Coast Regions with Temperate Climates - Volume II," CR 82.003,

Regions with Warm Humid Climates - Volume III," CR 82.004,

The Pacific Northwest - Volume IV," CR 82.005, and

Warm California Climates - Volume V," CR 82.006.

The original five-volume set was developed and written by Monika and Ed Lumsdaine at New Mexico State University, Las Cruces, New Mexico. The work was managed by Ed Durlak of the Naval Civil Engineering Laboratory, Port Hueneme, Calif., under Navy Contract N62583-79-MR-585 and the reports were published in October 1981.

The present work was funded by the Naval Civil Engineering Laboratory, and managed by Charles Miles and Ed Durlak under MIPR numbers N68305-82-MP-20006 and N68305-82-MP-200010, respectively. Although many features of the original documents have been retained, the following improvements and additions will greatly increase the usefulness of the new manual:

(1) The design calculation procedure has been improved and is faster than the original method.

(2) Performance correlations for a total of 109 reference passive solar designs have been generated. (Thirteen correlations were available in the original reports.)

(3) The procedures have been generalized by characterizing different climate types with an appropriate weather parameter, thereby eliminating the need for separate regional manuals.

(4) The new procedures are applicable to townhouses and larger dormitory-type buildings as well as to single-family detached residences.

(5) Performance correlations for passive solar retrofits to concrete block buildings are included in these procedures. Because of the prevalence of concrete block buildings at naval installations, these new correlations should be especially useful.

The report in its present form is not considered complete and will be updated as new results become available in succeeding years. In particular, the first revision will contain information on thermosiphoning air panels and attached sunspaces. Future revisions will also address the cooling problem in a more quantitative manner than is possible at present.

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1. INTRODUCTION

1.1. Passive Solar Buildings: A General Description

A passive solar building is one in which the flow of heat from solar energy is achieved by natural means. Thermal conduction, free convection, and radiation are used to transport heat rather than the pumps and blowers associated with active solar heating systems. In most cases, the elements of a passive solar system are integral parts of the building for which heat is provided. A direct gain building, for example, admits sunlight through ordinary south-facing windows that have good exposure to the low winter sun. The sunlight bounces around the interior until most of it is absorbed on the bounding surfaces. The absorbed solar energy is transformed into heat; part of it serves to meet the current heat load of the building whereas the remainder is stored in the structural mass for later use after the sun has set.

Because of the integral nature of passive solar buildings, it is not possible to design the structure independent of the heating system as is usually done with active systems. Instead, we must consider the solar

characteristics of the building from the initial phases of the design process to completion of the construction documents. A well-designed passive solar building is comfortable, energy efficient, and very reliable because of its inherent simplicity of operation. However, a poor design, lacking some or all of these desirable characteristics, may be very difficult to modify after construction is complete and the problems become manifest. The integrated nature of passive solar buildings has, therefore, necessitated the development of a new approach to building design that couples solar/thermal considerations with the more traditional concerns of form and structure.

1.2 Purpose of the Manual

The primary purpose of this manual is to make the results of recent scientific research on passive solar energy accessible to professionals involved in building design or design evaluation. By so doing, we hope to facilitate transfer of this relatively new technology from the research laboratory to the drawing board and the construction site. A successful transfer will greatly improve the energy efficiency of both new buildings and many existing buildings that are suitable for passive solar retrofits. This manual is addressed principally to prospective designers of passive solar buildings or passive solar retrofits because the architectural design process is complex and multifaceted, and because its practitioners must be given every consideration if they are to incorporate a new building technology into their established practice. However, good passive solar designs are of little value if they are rejected during the evaluation process in favor of more conventional but less efficient structures. We have, therefore, attempted to provide simple procedures for assessing the performance of existing designs so that the design evaluation process can be improved. Consequently, engineers and architects involved in proposal evaluation should also find this manual useful.

1.3 How to Use the Manual

Readers who are already acquainted with the field of passive solar energy may choose to skip the next chapter, which deals with basic concepts. Chapter 2 is intended to provide the newcomer with a concise overview of passive solar building technology. The characteristics of the various types of passive solar heating systems are described and the cooling implications of these systems are discussed.

Chapter 3 addresses variations in climate and the broad implications of those variations for passive solar design. We define a weather parameter that

characterizes the severity of the winter heating season and present a contour map of the continental United States that divides the country into four climatic regions on the basis of the characteristic parameter. Additionally, a second set of contours that characterize the amount of sunshine available to meet the heating load is presented on a separate map. This chapter provides the basis for design guidelines that are climate specific and should at least be scanned by even the more advanced readers.

Guidelines for the schematic phase of design, presented in Chap. 4, are intended to permit the designer tentative specification of the gross characteristics of his building in a manner that will assure acceptable performance in his particular climate region. The preliminary or schematic design may then be analyzed and refined by using the fast solar load ratio (FSLR) method of design analysis that is presented in Chap. 5. The FSLR method enables the user to quickly estimate the annual auxiliary heat requirements of passive solar buildings. Procedures for applying the method to single-family detached residences, townhouses, and large dormitory-type residences or office buildings are discussed.

Finally, in Chap. 6, we present a sample design analysis that illustrates the use of the design guidelines and the FSLR method provided in the manual. A four-plex multifamily housing unit was selected for analysis because many of the issues that arise when dealing with larger buildings were necessarily considered in the analysis.

In summary, this manual should provide the reader with enough information and guidance to enable him to design or evaluate passive solar buildings in the continental United States.

2. BASIC CONCEPTS

2.1. Direct Gain Heating

A direct gain building is a type of passive solar system in which sunlight enters the living space through windows and other transparent apertures as illustrated schematically in Fig. 2.1. The solar gains serve either to meet part of the concurrent heat load of the structure or are stored in the building mass to meet heating needs that arise later after the sun has set. Space heating requirements not satisfied by solar gains are provided by conventional back-up systems that generally use nonrenewable sources of energy. Other incidental sources of internal heat attributable to people, lights, appliances, and office equipment displace part of the thermal load. For single-family detached residences, internal-source heating is usually a small part of the total requirement, but for large office buildings the internal loads may dominate the thermal response.

As indicated in Fig. 2.1, thermal insulation is placed on the outside of massive elements of a direct gain building shell to avoid isolating the mass from the living space, thereby neutralizing its effectiveness as a thermal storage medium. Floor slabs can contribute to the heat storage capacity of a structure, provided they are not isolated by carpets and cushioning pads. It is advisable to limit losses from floor slabs by providing perimeter insulation on the outside of the foundation walls, but placing insulation beneath the slab is not generally cost effective. An earth berm is often placed on the north side of passive solar buildings to provide extra protection from cold winter winds.

Also illustrated in Fig. 2.1, an overhang is used to shade the solar aperture from the high summer sun while permitting rays from the low winter sun to penetrate and warm the living space. In climates that are relatively warm and sunny, an overhang is not sufficient to prevent serious aggravation of the summer cooling load.[1] Sky-diffuse and ground-reflected radiation enter the living space despite the overhang, and one must prevent the resultant unwanted solar gains by using internal or external reflective shades (drapes with a white liner will help a lot) or movable insulation. The use of movable insulation is strongly recommended because of the degree of thermal control it allows. During the winter, movable insulation can be used to limit nighttime heat losses, whereas during the summer it controls unwanted solar radiation and conductive heat gains during the daylight hours.

Usually, two glazing layers are mounted in direct gain apertures. A single glazing layer is undesirable because of the large heat losses that occur, particularly at night. In very cold climates, triple (or even quadruple) glazing is advisable on systems lacking movable night insulation.

Direct gain buildings have relatively high market appeal because they involve less departure from conventional construction than other types of passive solar heating systems. They can be effective even in very cold climates if multiple glazings or movable insulation are employed to control heat losses through the aperture. Direct gain buildings may overheat during sunny winter days if the aperture is too large or if inadequate thermal storage mass has been provided. They may also be susceptible to glare and fabric degradation caused by admission of sunlight into the living space. The best procedure for minimizing these problems is to distribute the transmitted solar radiation as uniformly as possible through appropriate window placement and the use of diffusive blinds or glazings.

On the positive side, direct gain buildings are attractive and provide occupants with good visual access to the outside. The incremental cost relative to an otherwise comparable nonsolar building is small, especially if the structure is inherently massive (as is much of the concrete-block housing at military bases). When properly designed for their location, direct gain buildings provide a cost-effective means of reducing energy consumption for space heating without sacrifice of comfort or aesthetic values.

2.2. Daylighting

The daylight delivered to the interior of direct gain buildings is a secondary benefit that is available year-round. Pleasing uniform illumination can be achieved by using blinds that reflect sunlight toward white diffusive ceilings. In larger office buildings the artificial lighting system imposes a significant load on the cooling system during the summer months. The load on the cooling system can be reduced by daylighting because the fraction of visible light in the solar spectrum is greater than the visible fraction of incandescent or fluorescent lighting.

2.3. Thermal Storage Walls

A thermal storage wall is a type of passive solar heating system in which the primary thermal storage medium is placed directly behind the glazing of the solar aperture, as illustrated in Fig. 2.2. The outer surface of the storage wall is painted a dark color to promote solar absorption. This arrangement

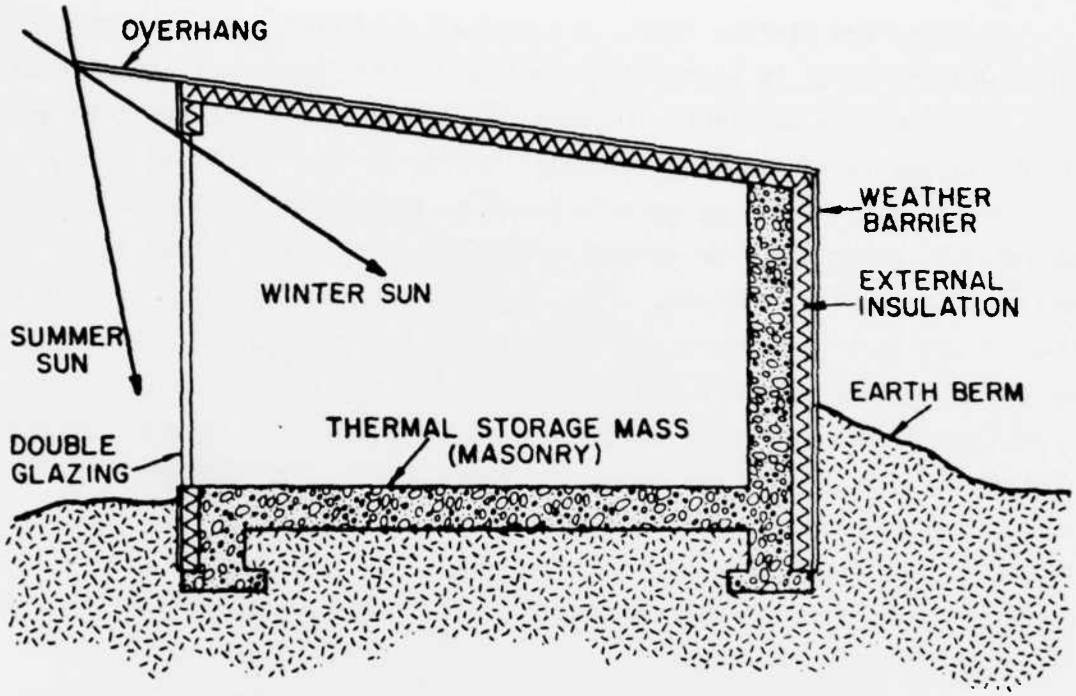

Fig. 2.1. Schematic of direct-gain building.

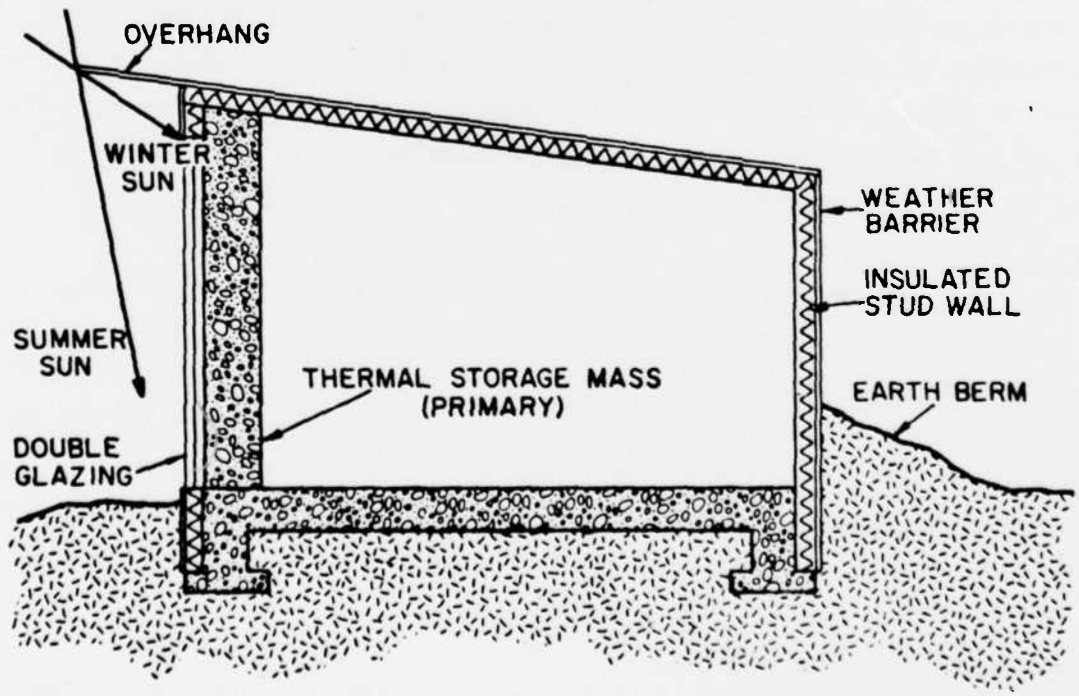

Fig. 2.2. Schematic of thermal storage wall.

generally yields improved performance over direct gain systems because the living space is better isolated from the outdoor environment. The massive thermal storage wall reduces nighttime heat losses during the cold winter months and limits unwanted heat gains during hot summer days.

2.3.1. Trombe Wall. A Trombe wall is a thermal storage wall that employs solid, high-density masonry as the primary thermal storage medium. The thickness of the masonry wall may range from 6 to 18 in. depending on the amount of sunshine available at the building site. In general, thicker walls are desirable in sunnier climates. Because of the moderating effect of the massive wall, the indoor environment behind a Trombe wall is more stable than that in a direct gain building. There is less tendency to overheat on clear winter days. Because of thermal lag, the inside temperature of the mass wall tends to be at a maximum during the evening hours when most residential buildings are occupied and the building heat load is large.

2.3.2. Vented Trombe Wall. A vented Trombe wall is one that has vents cut through the mass wall at the top and bottom. During the day, air between the inner glazing and the absorbing surface of the mass wall is heated by convection from the hot surface and rises, passing through the upper vent into the living space. The hot air leaving the air gap is replaced by cool air flowing into the lower vent from the living space. This thermosiphon effect improves the efficiency of a Trombe wall by removing heat from the hot absorbing surface and transferring it to the building interior. A more rapid warm-up after the sun rises can also be expected because the bouyant forces in the air gap develop much more quickly than heat can travel through the masonry wall by thermal conduction. At night, steps must be taken to prevent reverse flow through the vents that would remove heat from the interior. Passive backdraft dampers or manually operated vent closures are acceptable solutions. Because thermocirculation vents can sometimes cause overheating on clear winter days, a manual closure scheme should be considered in sunny climates.

2.3.3. Concrete Block Wall. Ordinarily, one would not consider making a Trombe wall out of concrete building blocks because solid masonry walls have a higher heat capacity and perform better. However, concrete-block buildings are very common in the Navy and provide an excellent opportunity for passive solar retrofitting. One need only glaze the south-facing block walls to turn a surface that loses heat into a passive solar aperture that develops a net heat gain. The performance will not be as good as that obtainable from a solid

masonry wall but the cost is minimal and energy savings are significant. If better performance is desired, the concrete-block cavities can be filled with mortar. This strategy might be difficult to implement as a retrofit but should be easy to apply in new construction.

2.3.4. Water Wall. A water wall is a thermal storage wall that employs water, usually in cylindrical, metal or fiber glass containers, as the thermal storage medium. The cylindrical containers are placed immediately behind the glazed solar aperture in a vertical position. Typically, there are air gaps between the cylinders that allow convective heat transfer between the inner layer of glazing and the building interior. This effect, in addition to convective heat transfer within the water from outer to inner surface, reduces the thermal barrier effect between indoor and outdoor environments. However, the volumetric heat capacity of water is roughly twice that of masonry, enabling the designer to achieve very high building heat capacities at low cost and with little wasted space. The high heat capacities obtainable with water walls more than offset the problems caused by convective heat transfer and lead to stable high-performance systems.

2.4. Other Passive Heating Systems

The design method presented in this manual is applicable only to direct gain and thermal storage wall systems at this time. Other viable systems exist and will be incorporated into the manual as needs arise and resources permit. For the present, we give only a brief description of the other system types.

2.4.1. Attached Sunspace. An attached sunspace is a combination of direct gain and thermal storage wall approaches. The building consists of two thermal zones: a direct gain sunspace in which the temperature is not controlled and an indirectly heated living space that is separated from the sunspace by a thermal storage wall or by an insulated wall. If the sunspace is separated by an insulated wall, thermal storage mass is usually provided by placing water containers within the enclosure.

In either case, doors and windows are generally provided to permit convective transfer of heat from the sunspace to the living space. The sunspace is frequently used as a greenhouse and, when the temperature permits, as an enclosed patio.

2.4.2. Thermosiphon. A thermosiphon resembles an active solar heating system because the collector and thermal storage mass are separate and are thermally coupled only by convective heat transfer. However, in a thermosiphon

the convective loop between collector and storage is driven by bouyancy forces rather than by fans as in an active system. The storage mass is located above the collector where solar radiation is absorbed and heat is transferred to the adjacent air. The hot air passes out the top of the collector, rises to the thermal storage medium where it loses heat, and falls back down to the bottom of the collector, completing the loop.

2.4.3. Thermal Storage Roof. A thermal storage roof is similar to a thermal storage wall except that the interposed thermal storage mass is located on the building roof. Usually, water is used for the thermal storage mass, either in a pond or in bags.

2.5. Cooling Implications

Two cooling problems are sometimes associated with passive solar heating systems. First, a passive system may deliver too much heat on a clear winter day, causing the building to overheat; second, the system may deliver unwanted heat during the summer, thereby inducing an incremental cooling load.

2.5.1. Winter Overheating. Passive solar systems that are sized to meet a large fraction of the building heat load will sometimes overheat the structure on clear winter days. This is a manageable problem that can be controlled by one or more of the following measures:

(1) Use large amounts of thermal storage mass to reduce the temperature swings.

(2) Ventilate the interior when excess temperatures occur.

(3) Limit solar exposure by using drapes, blinds, shutters, or movable insulation.

One might also eliminate the overheating problem simply by using small solar apertures that meet only a small fraction of the building heat load. However, the small aperture approach does not take full advantage of the solar resource available in sunny climates and, in any case, the countermeasures suggested above are also helpful in reducing the incremental summer cooling load that is discussed below.

2.5.2. Incremental Summer Cooling Load. Unfortunately, passive solar heating systems are functional during the cooling season unless definite steps are taken to disable them. The traditional solution is to use an overhang that allows for full exposure of the solar aperture during the heating season but shades the aperture from direct radiation during the summer months. This

simple procedure is all that is required for thermal storage walls in relatively cool climates. But direct gain apertures on buildings in warm climates must generally be covered to avoid inducing an incremental cooling load that requires more energy to displace than has been saved by solar heating during the winter. (This effect tends to be less of a problem with Trombe walls than with direct gain systems.) A full cover is sometimes required because the flux of sky-diffuse and ground-reflected radiation is significant and cannot be controlled with an overhang. Direct gain apertures may be covered with drapes, reflective shades, reflective blinds, or movable reflective insulation. The cover can, of course, be partially opened to provide an appropriate level of daylighting and visual access to the outside. External covers are more effective than internal covers.

3. GENERAL CLIMATIC CONSIDERATIONS

3.1. Important Weather Parameters

The heating degree days (DD) value for a period of one day is calculated by summing the difference between the base temperature of interest and the outside ambient temperature for each hour of the day. If an hourly difference happens to be negative, we set DD equal to zero for that particular hour. Using this procedure for determining the daily DD, one can easily obtain the heating degree days for a time period of arbitrary length, say a month or a year, simply by summing the daily contributions that occur during the period. Consequently, the amount of heat required to maintain a building at the base temperature (in the absence of internal sources) for one month is given by

$$Q_L = TLC \cdot DD \text{ (Btu)} \tag{3.1}$$

where TLC (Btu/°F day) is the total load coefficient of the building and DD is the number of degree days occurring during the month. The total load coefficient is defined as the amount of heat required to maintain a one degree difference between the inside and outside ambient temperatures for a period of 24 hours. The heat load for the entire heating season is obtained simply by adding the monthly loads given by Eq. (3.1). Thus, the DD is an important climate parameter because it is directly proportional to the building heat load. The units of degree days are °F day, but herein we follow the common practice of using the symbol DD to represent the units.

The amount of solar radiation, VT2, that is transmitted through one square foot of a vertical, south-facing, double-glazed aperture during a given month is a second important weather parameter. The parameter VT2 is important because it quantifies the solar resource available for passive space heating. In the next section we will show that various combinations of the parameters VT2 and DD can be used to characterize climates with regard to the relative importance of conservation and passive solar measures for reducing auxiliary heat consumption.

3.2. Climate Regions Based on Importance of Conservation Measures

As we shall explore in more detail in Chap. 5, the fraction of the total monthly heating load of a building that can be met by passive solar strategies depends on certain features of the building design and the weather parameter S/DD, where S is the monthly solar radiation absorbed by the passive system. Depending on the building characteristics and the type of passive heating

system involved, S is usually between 0.9 VT2 and 1.0 VT2 for double-glazed systems. We can, therefore, employ the parameter VT2/DD to obtain a rough idea of the passive solar potential of a particular climate during a given month. If we wish to know the passive solar potential of a particular climate for the entire heating season, we take the degree day weighted average of VT2/DD for all the months in the heating season. We use the notation, $\overline{VT2/DD}$, to indicate the weighted average.

Now, climates with like values of the characteristic parameter, $\overline{VT2/DD}$, can be expected to yield like values of the solar heating fraction, SHF (the fraction of the total building load met by solar energy), for identical buildings. High values of $\overline{VT2/DD}$ yield high SHFs and, conversely, low values of $\overline{VT2/DD}$ yield low SHFs. It follows that in climates having low $\overline{VT2/DD}$ ratios, conservation measures (insulation, weather stripping, etc.) will be more important than in climates having higher values. Clearly, if only small fractions of the building load can be met by solar energy, one must seek to reduce that load by appropriate conservation measures to significantly reduce energy consumed for space heating. A map of the continental United States with contours of constant $\overline{VT2/DD}$ is presented in Fig. 3.1. The uppermost, middle, and lowest contours are given by VT2/DD = 30, 50, and 90 Btu/ft^2°F day, respectively. As indicated on the map, the four climate regions defined by the contours are referred to as mild (MI), moderate (MO), harsh (HA), and very harsh (VH). General descriptions of these climate regions and qualitative comments concerning regionally appropriate design are presented in the following four subsections.

3.2.1. Mild Climates. The mild climate region includes the southern third of California and Arizona, small parts of the southern extremes of New Mexico, Texas, and Louisiana, and most of the Florida peninsula.

In this region the winter heating load varies from small to nil and, in any case, there is plenty of sunshine available to meet most of the small loads that arise. In general, the heat loads can be met using less expensive direct gain systems with relatively small solar collection apertures. Summer cooling loads can be quite high in this region, however, sometimes several times larger than the heating load. Thus, it is particularly important to make sure that the small amount of energy saved by passive solar heating is not negated by the associated incremental cooling load. The use of defensive countermeasures is strongly recommended. Because of the high solar heating

fractions obtainable in this region, conservation measures are less important than in areas further north.

3.2.2. Moderate Climates. The moderate region includes most of California, the southern half of Nevada, the central third of Arizona, and most of New Mexico, Texas, Louisiana, Mississippi, Alabama, Georgia, and South Carolina. The Florida panhandle and most of the North Carolina coast are also included.

Thermal storage wall and direct gain systems are both appropriate in this region. More insulation is required and, because of the larger ratio of heating load to cooling load, larger solar collection apertures are the rule.

3.2.3. Harsh Climates. The harsh region includes most of Washington, Oregon, Idaho, Nevada, Wyoming, Utah, Colorado, Nebraska, Kansas, Oklahoma, Missouri, Arkansas, Kentucky, Tennessee, Virginia, and North Carolina. Northern parts of Arizona, New Mexico, Texas, Mississippi, Alabama, Georgia, and South Carolina are also included as well as southern parts of Montana, South Dakota, Iowa, Illinois, Indiana, and West Virginia. Finally, the harsh region includes coastal areas in Massachusetts, Rhode Island, New York, New Jersey, Maryland, and all of Delaware.

At the northern extremes of the harsh region, night insulation should be considered on direct gain apertures. Heating loads are appreciable in this region but it is still necessary to exercise care not to unduly aggravate the summer cooling load. Conservation measures are very important.

3.2.4. Very Harsh Climates. The very harsh region includes all of North Dakota, Minnesota, Wisconsin, Michigan, Ohio, Vermont, New Hampshire, and Maine; most of Montana, South Dakota, Iowa, Illinois, Indiana, West Virginia, Connecticut, Pennsylvania, and Massachusetts: and parts of Idaho, Wyoming, Nebraska, Kentucky, Virginia, Maryland, New Jersey, and Rhode Island.

Near the boundary between the harsh and very harsh regions or in areas with greater than average sunshine, direct gain systems without night insulation may still be viable. However, if night insulation is not employed, the direct gain apertures should be kept fairly small. Thermal storage walls are preferred in the very harsh region and the addition of night insulation may be advisable near the northern boundary. Because relatively small solar savings fractions are obtainable in this region, heavy use of conservation measures is critical to achieving energy-efficient performance.

3.3. Climate Regions Based on Solar Availablity

To define climate regions on the basis of the availability of solar energy as a space-heating resource, we have calculated the degree day weighted average of the monthly radiation transmitted through vertical, south-facing, double-glazed apertures. The notation $\overline{VT2}$ is used to represent the weighted average.

The degree day weighting has been employed because solar radiation is most valuable when the heating load is highest and is of no value (as a space-heating resource) when the heat load is zero (or when DD is zero).

A map with contour lines of constant $\overline{VT2}$ is presented in Fig. 3.2. The contours divide the country into five solar regions that we label as follows:

(1) Most Sunny (MS): $\overline{VT2} > 30$ (KBtu/ft^2)

(2) Very Sunny (VS): $25 < \overline{VT2} \leq 30$ (KBtu/ft^2)

(3) Sunny (SU): $20 > \overline{VT2} \leq 25$ (KBtu/ft^2)

(4) Cloudy (CL): $15 < \overline{VT2} \leq 20$ (KBtu/ft^2)

(5) Very Cloudy (VC): $\overline{VT2} \leq 15$ (KBtu/ft^2)

These five regions cut across the four principal climate regions defined in Fig. 3.1 and form subregions that determine appropriate sizes for solar apertures.

As a general rule, the sunnier subregions of a particular principal climate region should have the larger solar apertures. The largest apertures will occur in the sunnier parts of the moderate and harsh principal climate zones. Apertures will be relatively small in the warm region because the heat load is small, and relatively small in the very cold region because heavy use of conservation measures is the preferred strategy. Some general comments on the solar regions defined in Fig. 3.2 are presented in the next five subsections.

3.3.1. Most Sunny Region. This region is limited to the desert southwest and includes major parts of Nevada, Arizona, and New Mexico. Subregions in which the most sunny region overlaps the harsh region are ideal for passive solar heating strategies because of the coincidence of a substantial heating load and excellent solar availability. The most sunny/moderate subregion is also quite good for passive solar heating.

3.3.2. Very Sunny Region. The very sunny region forms a complex crescent that bounds the most sunny region. It forms a large, very sunny/harsh

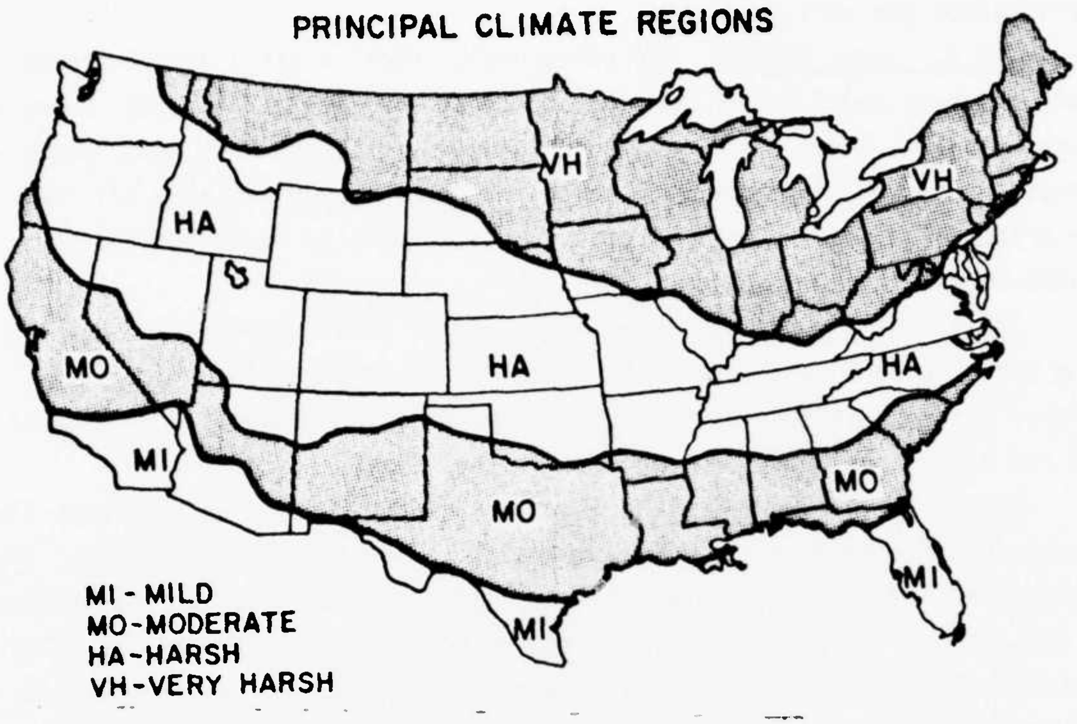

Fig. 3.1. Principal climate regions in the continental United States for passive solar design.

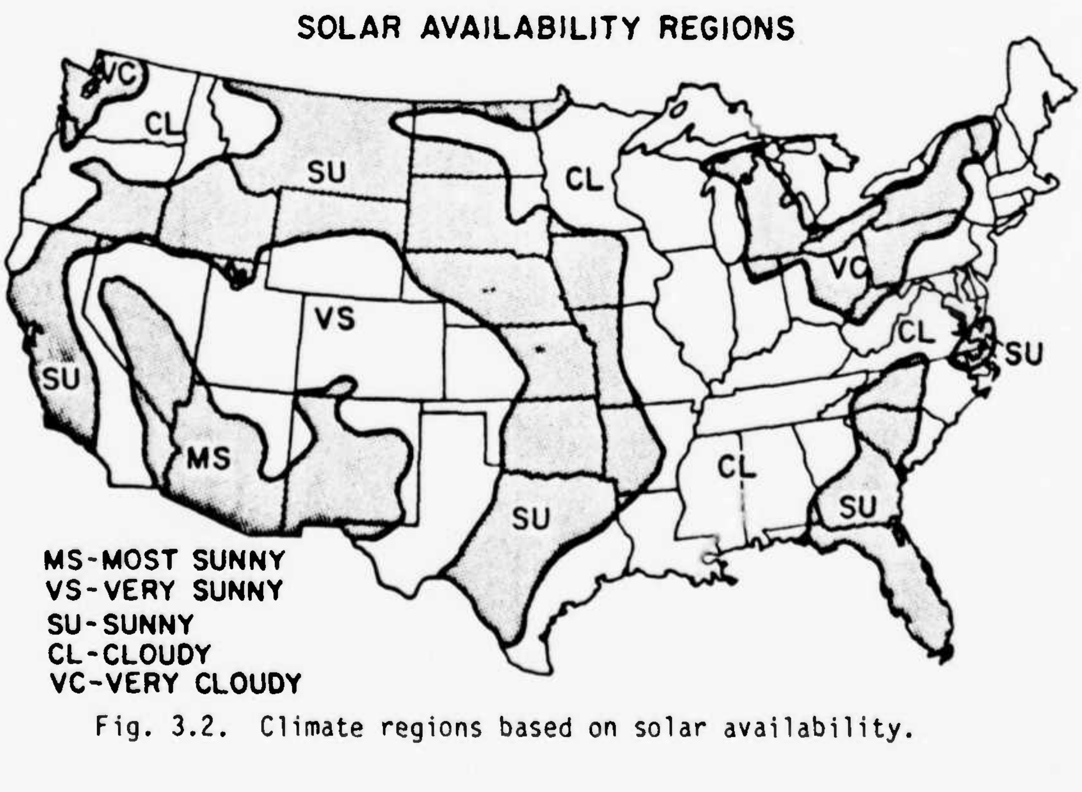

Fig. 3.2. Climate regions based on solar availability.

subregion and a smaller, very sunny/moderate subregion in which passive solar applications are very desirable.

3.3.3. Sunny Region. The sunny region forms a still larger crescent about the very sunny region and includes parts of Florida, Alabama, Georgia, South Carolina, North Carolina, and Virginia. The sunny area cuts completely across the country from north to south and forms subregions with all four of the principal climate types. A broad range of passive solar designs are viable across these subregions.

3.3.4. Cloudy Region. The cloudy region also traverses the country from north to south and forms four types of subregions among which many passive designs are feasible. Parts of the Pacific northwest, the Midwest, and the eastern seaboard are included in the cloudy region.

3.3.5. Very Cloudy Region. The very cloudy region includes only the extreme Pacific northwest and the central to eastern Great Lakes area. The Great Lakes area, where the very cloudy region overlaps the very harsh region, is the poorest location in the continental United States for passive solar heating. The Pacific northwest area overlaps the cold climate region and is slightly better suited for passive solar applications.

4. GUIDELINES FOR SCHEMATIC DESIGN

During the schematic phase of architectural design, one is involved in developing a rather coarse picture of the desired building. At this point in the design process, design-analysis techniques are of little use because the building is not well defined. What is needed during schematic design is a set of rules of thumb to help the designer select starting-point values for the principal design parameters. In the sections that follow, we present climate-specific guidelines for determining the initial design.

4.1. Building Shape and Orientation

Passive solar buildings should be elongated in the east/west direction such that a large south-facing surface is presented to the low winter sun for heat collection, and small east- and west-facing surfaces are presented to the northerly rising and setting summer sun to minimize unwanted heat gains. The aspect ratio (east/west dimension divided by north/south dimension) should generally be at least 1.67, although much larger values would be appropriate for large dormitory-like structures. It is best if passive solar buildings are no more than two zones deep in the north/south direction because overall performance is enhanced if solar heat collected in the southern zone can be transported for use in the northern zone. Multistory buildings are appropriate candidates for passive solar heating, provided the depth in the north/south direction is limited to two principal zones and the aspect ratio is kept above 1.67.

Departures of up to 30° from a true south orientation are permissible; performance penalties will be less than 10%. An easterly bias in orientation is preferred if a more rapid warm-up in the morning is desired, whereas a westerly bias will yield better performance in buildings that will be occupied after working hours because of the improved phasing of solar resource and heat load.

4.2. East, West, and North Windows

Windows not facing south should be kept small while complying with local building codes. Particularly in cold climates, most of the nonsouth window area should be placed on the east or west side of the building to take advantage of solar gains available during the early morning and late afternoon.

All windows not facing south should have at least two glazing layers and, in the harsh or very harsh regions, it would by wise to consider the use

of triple glazing. Movable opaque covers should be provided on east- and west-facing windows to screen out unwanted sun during the summer.

4.3. Type of Passive System

Only two types of passive solar heating systems are currently addressed in this manual. Thermal storage wall systems are massive south-facing walls covered externally with one or more glazing layers. Solar radiation is transmitted through the glazing and absorbed on the mass surface. The glazing is opaque to infrared (IR) radiation emitted by the hot storage wall so that losses back to ambient are limited. Heat migrates through the storage medium and is introduced to the living space upon reaching the inside surface. Three types of storage media are considered in this manual: (1) concrete or brick, (2) water, and (3) 8-in. concrete building block, with cores empty or filled with mortar. Direct gain systems involve ordinary south-facing windows that introduce solar energy directly to the living space. Unless the aperture is sized to meet daytime heating needs only, it is generally necessary that direct gain buildings be fairly massive so that heat may be stored in the building elements for nighttime use. In later revisions of this manual, we hope to include information on attached sunspaces and thermosiphoning air panels.

Thermal storage walls, particularly those without vents, provide more stable indoor environments than direct gain systems. The mass of the wall exerts a moderating effect on inside temperatures and, consequently, overheating is seldom a problem. Also, because of the thermal-lag effect associated with heat transport through masonry storage walls, solar heat delivery is at a maximum during the evening hours when it is most needed in residential applications. As an additional benefit, the mass wall provides a buffer against high outside ambient temperatures during the cooling season.

Thermal storage wall systems are applicable in all four climate regions defined on the contour map in Fig. 3.1. In the milder climates, defensive countermeasures may be required to limit solar heat gain during the cooling season. In the harsher winter climates one may need additional glazing layers or possibly even night insulation to achieve adequate solar gains during the heating season. Bear in mind that winter night insulation that is intended to increase the net diurnal heat gain of the solar aperture can be used in the reverse mode during the summer, that is, one may have the aperture insulated

during the day to limit unwanted solar gains and remove the insulation at night to facilitate cooling, if the outside ambient temperature is low enough. Recommended glazing levels for thermal storage walls with or without night insulation are presented in Table 4.1 for the four principal climate regions. Defensive strategies for controlling summer heat gains are also suggested. The purpose of external covers is to shade the aperture from direct and diffuse radiation. A fixed overhang provides partial protection from direct radiation and a seasonal overhang achieves the same objective, but more effectively because of its adjustable feature. In the present context, venting refers to allowing heat built up between the thermal storage wall surface and the inner glazing to escape from the air gap. A natural circulation pattern will be established if vents to the outside are placed at the top and bottom of the storage wall.

Direct gain systems have the advantages of being less expensive than thermal storage walls, at least for inherently massive structures, and involve less departure from conventional building design. However, they are more sensitive to external conditions and, if not properly designed, may be prone to overheat during the winter, aggravate the cooling load during the summer, or lose so much heat through the aperture during cold winter nights that net heat gains are minimal or even negative. The rules of thumb presented in Table 4.2 should help the designer avoid these problems.

A mixture of thermal storage wall and direct gain systems on a single building is desirable because one is able to take advantage of the best features of both designs. Thermal storage walls

(1) are thermally stable,
(2) deliver maximum heat in the evening, and
(3) yield relatively high performance.

Direct gains systems

(1) provide quick warm-up in the morning,
(2) allow for a view to the south,
(3) provide daylighting,
(4) are especially easy to control by movable insulation or shades, and
(5) are relatively inexpensive.

Procedures for estimating the performance of direct gain and thermal storage wall systems, individually or in combination, will be presented in Chap. 5.

TABLE 4.1

RULES OF THUMB FOR THERMAL STORAGE WALL ELEMENTS

SYSTEMS WITH NO NIGHT INSULATION

Climate	No. of Glazings	Defensive Cooling Strategy
Mild	1	External covers
Moderate	1-2	External covers
Harsh	2	Seasonal overhang and venting
Very Harsh	2-3	Fixed overhang and venting

SYSTEM WITH R5 NIGHT INSULATION

Climate	No. of Glazings	Defensive Cooling Strategy
Mild	1	Seasonal cover
Moderate	1	Seasonal cover
Harsh	1-2	Seasonal cover
Very Harsh	2	Seasonal cover

TABLE 4.2

RULES OF THUMB FOR DIRECT GAIN SYSTEMS

SYSTEMS WITH NO NIGHT INSULATION

Climate	No. of Glazings	Defensive Cooling Strategy
Mild	2	External covers
Moderate	2	Internal shades or blinds
Harsh	2-3	Drapes and seasonal overhang
Very Harsh	3	Drapes and fixed overhang

SYSTEM WITH R5 NIGHT INSULATION

Climate	No. of Glazings	Defensive Cooling Strategy
Mild	1	Seasonal cover
Moderate	1-2	Seasonal cover
Harsh	2	Seasonal cover
Very Harsh	2-3	Seasonal cover

4.4. Insulation Levels

Recommended levels of insulation depend only on the principal climate region in which the building is located (see Fig. 3.1) and on the building size. The R-values (thermal resistance) of wall insulation should lie in the following intervals for small (1500 ft^2), one-story, single-family detached residences:

(1) Mild Region: $RWALL_o$ = 10 to 15 (ft^2-°F-h/Btu)

(2) Moderate Region: $RWALL_o$ = 15 to 20 (ft^2-°F-h/Btu)

(3) Harsh Region: $RWALL_o$ = 20 to 25 (ft^2-°F-h/Btu)

(4) Very Harsh Region: $RWALL_o$ = 25 to 30 (ft^2-°F-h/Btu)

These recommendations are consistent with the results of a study on the economics of mixing conservation measures and passive solar strategies conducted for the US Department of Energy by Los Alamos National Laboratory.[2]

Larger buildings derive a greater benefit from incidental heating by internal sources because of the reduced external surface area relative to the heated floor area. For two-story, single-family residences, townhouses, and dormitories or office buildings, the R values of the wall insulation should be scaled down from the above recommendations as follows:

$$RWALL = \frac{1}{3}\left(\frac{A_e}{A_f}\right) RWALL_o \quad ,$$

where RWALL is the scaled R-value, A_e is the exposed or external surface area of the building (common walls between townhouse units, for example, are excluded but ground-level floors are included), and A_f is the heated floor space of the building. This scaling credits larger buildings for their more effective utilization of internal source heating during the winter by allowing reduced levels of wall insulation.

It is common practice to employ higher levels of insulation in the ceiling than in the wall for three reasons:

(1) It is cheaper to insulate the ceiling than the wall.

(2) Stratification causes larger heat-loss rates per square foot of ceiling than per square foot of wall.

(3) Solar gains on roofs during the summer can cause unwanted heating of the living space beyond that caused by high ambient air temperatures alone.

We therefore recommend that the total R-value of the roof be scaled directly with the wall R-value as follows:

RROOF = 1.5 RWALL.

Heat losses through building perimeters and through fully bermed basement walls are limited by contact with the soil so that insulation levels need not be as high as the values recommended for exposed external walls. The following formulas yield reasonable insulation levels for these surfaces:

RPERIM = 0.75 RWALL, and
RBASE = 0.75 RWALL.

Ordinarily, floors are not insulated so as to assure that pipes located below do not freeze. Because of widely varying conditions beneath ground-level floors, it is difficult to recommend specific insulation levels. However, if there is no problem with pipes freezing, a reasonable level would be

RFLOOR = 0.5 RWALL.

Before leaving this section, we wish to caution the reader that these insulation levels are recommended only as starting-point values. We expect design-analysis calculations to be performed that will allow one to fine tune the values of all important design parameters.

4.5. Solar Collection Area

Our rule of thumb for sizing solar apertures is based on achieving annual productivities that are high enough to yield a payback period of roughly ten years. Annual productivity is the amount of useful solar heat delivered to the building by one square foot of collection aperture during a full heating season. High productivities are realized with relatively small apertures that are more efficient whereas large absolute energy savings are achieved with large apertures. By employing productivity in our sizing procedure rather than absolute energy savings we are assured that our designs will be cost effective at any location in the continental United States.

Four representative passive solar systems were considered in the development of our sizing rule. Two of the systems were double-glazed direct

gain designs; the first had no night insulation and the second had R9 night insulation. Both direct gain designs employed 4 in. of high-density concrete for thermal storage mass, spread over an area that was six times the size of the solar aperture. Two 12-in.-thick, high-density concrete Trombe walls were also considered. Both Trombe walls were double glazed and vented to the inside; one employed R9 night insulation and the second had none. Each of these four systems was assigned a different productivity because of the differences in representative costs per square foot of aperture. The assigned productivities are as follows:

Direct Gain--No night insulation: $P = 58{,}500\ \text{Btu/ft}^2$

Direct Gain--R9 night insulation: $P = 76{,}500\ \text{Btu/ft}^2$

Trombe wall--No night insulation: $P = 67{,}500\ \text{Btu/ft}^2$

Trombe wall--R9 night insulation: $P = 85{,}500\ \text{Btu/ft}^2$

Contour maps of aperture size in per cent of floor area were generated for each of the above systems using the indicated productivities. Differences among the four maps were small, so a single map was generated by taking the average of the aperture sizes obtained for the four different systems. The average-aperture-size contour map is presented in Fig. 4.1.

Figure 4.1 may be used for preliminary sizing of all direct gain and Trombe wall systems addressed in this manual. Systems that operate at higher efficiencies tend to be more expensive and, therefore, require higher productivities in order to pay back in about ten years. The higher productivities are achieved by keeping the aperture size about equal to that recommended for less efficient but cheaper systems. Thus, only a single contour map is required for initial aperture sizing.

The numbers appearing on the map in Fig. 4.1 give the aperture size in per cent of floor space for a single-family detached residence of 1500 ft^2. For larger structures, the ratio of collector area to floor area, A_c/A_f, should be scaled according to the following formula:

$$\frac{A_c}{A_f} = \frac{1}{3}\left(\frac{A_e}{A_f}\right)\left(\frac{A_c}{A_f}\right)_o ,$$

where A_e is the external surface area of the building and $(A_c/A_f)_o$ is the reference value of the collector-area-to-floor-area ratio from the contour map.

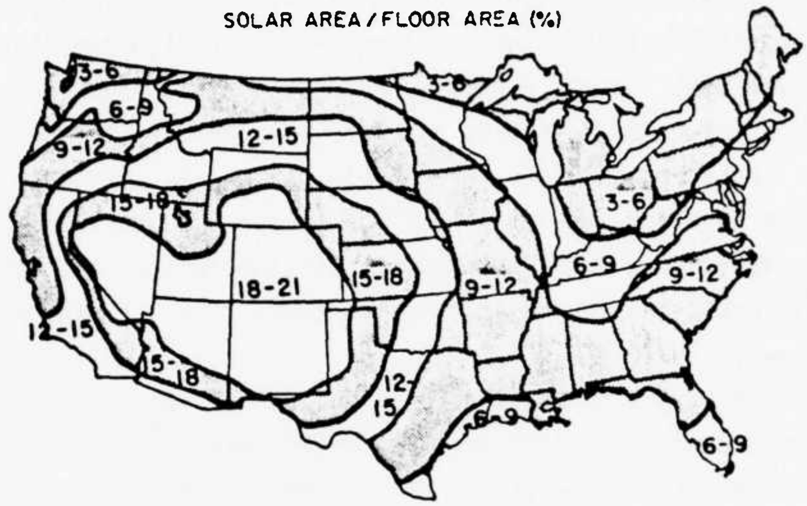

Fig. 4.1. Solar aperture area/floor area ratio in per cent (initial schematic design values) for direct gain and Trombe wall systems.*

If the solar collection aperture is not oriented due south, the size should be reduced to compensate for the lower productivities that result from off-south orientations. The following formula provides a reasonable correction for departures of up to 60° from due south.

$$\frac{A_c}{A_f} = \left(\frac{A_c}{A_f}\right)_{south} \cos\left(\frac{4}{5}\right) ,$$

θ = true south, correct for magnetic declination

where θ is the azimuth of the collector in degrees. The azimuth is zero for due south and positive to the east.

4.6. Thermal Storage Mass

The passive solar systems used to establish a sizing rule in the previous subsection had fixed amounts of thermal storage mass. The direct gain systems had 2 ft^3 of high-density concrete per ft^2 of aperture. The concrete has a volumetric heat capacity of 30 Btu/ft^3, which yields a system heat capacity of 60 Btu/ft^2 of solar aperture. The Trombe walls were 1-ft thick and, therefore, have a system heat capacity of 30 Btu/ft^2 of solar aperture.

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*Note: Large apertures occur where high-solar availability coincides with a large heat load. Small apertures occur where the solar availability is low or the heat load is small.

These heat capacities, which represent good intermediate values for both types of systems considered, are most appropriate in the sunny region (see Fig. 3.2), and values up to 25% lower are acceptable in the cloudy region. In the smaller, very cloudy region, reductions of 25 to 50% are permissible. However, in the very sunny and most sunny regions, one might consider using more thermal storage mass to minimize the possibility of winter overheating. Trombe walls up to 18-in. thick are appropriate in both regions as are direct gain buildings with 3 to 4 ft^3 of concrete per square foot of aperture. It is best to use thin layers of thermal storage mass with large surface areas in direct gain buildings to facilitate heat transfer to and from storage. Concrete is most effective in thicknesses of 4 in. or less, but layers up to 6-in. thick are permissible.

4.7. Schematic Design Worksheet

Worksheet No. 1 is provided to assist the user in organizing and recording the results of the schematic design process discussed in this chapter. The worksheet is self-explanatory except that the quantity, P_t, has a special definition. P_t is the total external perimeter of the heated floor space, A_f, selected for analysis. The floor space may occupy one or more levels in a building, and P_t is defined as the total external perimeter of all levels included in the analysis. Thus, for a two-story building that is being analyzed as a single unit, the total perimeter is the perimeter of the ground floor plus the perimeter of the upper floor. If the two-story unit is a duplex consisting of two distinct thermal zones separated by a vertical plane, one may choose to analyze the thermal zones separately. In this case, the length of the common wall separating the two zones must be subtracted from the perimeter of each level before summing to obtain P_t.

Additional worksheets will be presented in later chapters as more detailed design analysis procedures are introduced. Having once read and understood this design manual, the user should be able to rapidly specify appropriate starting-point values for the primary passive solar design parameters and proceed to completion of a detailed design analysis and refinement procedure using only the worksheets and the graphical and tabular information provided in the manual. We strongly suggest that the user carefully study the sample calculation presented in Chap. 6 where use of all of the worksheets is demonstrated.

WORKSHEET NO. 1
SCHEMATIC DESIGN PARAMETERS

Building Size

Heated floor space: A_f = ________ ft^2

Ceiling height: h = ________ ft

Total external perimeter: P_t = ________ ft

Note: Include external perimeter of each floor.

External surface area: $A_e = 2A_f + h \cdot P_t$ = ________ ft^2

External surface-area-to-floor-area ratio: A_e/A_f = ________

Insulation Levels

$RWALL_o$ = ________ ft^2 °F h/Btu

Note: $RWALL_o$ is obtained from the contour map in Fig. 3.1 and the insulation levels recommended in Sec. 4.4.

$RWALL = \frac{1}{3}\left(\frac{A_e}{A_f}\right) RWALL_o$ = ________ ft^2 °F h/Btu

RROOF = 1.5 RWALL = ________ ft^2 °F h/Btu.

$\left.\begin{array}{c}\text{RPERIM}\\ \text{or}\\ \text{RBASE}\end{array}\right\} = .75\ \text{RWALL}$ = ________. ft^2 °F h/Btu

Solar Aperture Size (Due south orientation)

$\left(\frac{A_c}{A_f}\right)_o$ = ________

Note: $\left(\frac{A_c}{A_f}\right)_o$ is obtained from the contour map in Fig. 4.1. Remember to convert from per cent to the fractional value before recording the quantity.

$A_c = A_f \left(\frac{A_c}{A_f}\right)_o \left(\frac{A_e}{A_f}\right) \Big/ 3$ = ________ ft^2

Building Orientation (Azimuth)

θ = ________ degrees

Note: Azimuth is zero for due south and positive to the east

Solar Aperture Size (Corrected for Off-South Orientation)

$A_c = \left(A_c\right)_{south} \left[\cos\left(\frac{4}{5}\theta\right)\right]$ = ________ ft^2

5. DESIGN ANALYSIS

The guidelines presented in the previous chapter should enable the designer to specify initial values for the design variables that are most strongly related to energy-efficient performance in passive solar buildings. Before proceeding any further with the design, an analysis that provides an estimate of the building's auxiliary heat requirements should be conducted. By repeating the analysis with different values of the primary variables it is possible to fine tune the original design in a manner that is consistent with the performance and economic goals of the project. The design-analysis procedure presented in this chapter is quick and accurate and, therefore, well suited to the design-refinement process. Before discussing the procedure, we present a set of definitions below that will aid the reader in his study of passive solar design analysis.

5.1. Definitions

5.1.1. Transmitted Solar Radiation (VT). The symbol VT is used to denote the amount of solar radiation transmitted through one square foot of a vertical solar aperture during a specified time period. We are usually most interested in one-month time periods because our performance correlations employ monthly weather data. The parameter VT characterizes the availability of sunshine as a space-heating resource during a particular month at a particular location. The symbols VT1, VT2, and VT3 are used to specifically denote the amount of radiation transmitted through single-, double-, and triple-glazed apertures, respectively. The glazing orientation may vary from 60° east to 60° west of south.

5.1.2. Solar-Aperture Absorptance (α). The solar-aperture absorptance is the fraction of transmitted solar radiation that is absorbed by the passive heating system. The fraction not absorbed is lost back through the glazing by reflection.

5.1.3. Absorbed Solar Radiation (S). The amount of radiation absorbed by a passive solar heating system per square foot of aperture is given by the product of the transmitted radiation and the aperture absorption, that is

$$S = \alpha VT.$$

5.1.4. Building Load Coefficient (BLC). The BLC is defined as the amount of heat that would be required to maintain the air temperature in a building

1°F above the outdoor ambient temperature for a period of one day if no heat losses or gains through the solar aperture were allowed. Thus, the BLC, which is expressed in units of Btu/°F day, provides a measure of how effectively the nonsolar elements of a building have been sealed and weather-stripped to reduce infiltration and insulated to reduce heat losses by conduction. A procedure for obtaining a quick estimate of the BLC will be presented in Sec. 5.2.2.

5.1.5. Thermostat Setpoint (T_{set}). This is the temperature setting of the thermostat that controls the auxiliary heating system in a passive solar building.

5.1.6. Base Temperature (T_b). The base temperature is the thermostat setpoint adjusted in a manner that accounts for the effect of internal-source heating on the building heat load. Internal source heating is that generated by people, lights, appliances, office equipment, or any other device not primarily intended as an auxiliary heat source. The base temperature is given by

$$T_b = T_{set} - Q_{int}/(BLC + 24 \cdot U_c \cdot A_c) \quad ,$$

where Q_{int} is the internal heat generation rate (Btu/day), U_c is the steady-state conductance of the solar aperture (Btu/h°F ft^2), and A_c is the solar-collection area. The base temperature is a useful concept in thermal analysis because the same amount of heat is required to keep a building at T_b in the absence of internal sources as would be required to maintain a temperature of T_{set} with an internal heating rate of Q_{int}.

5.1.7. Heating Degree Days (DD). The heating degree days for a one-day period is the hourly summation of the difference between a specified base temperature and the hourly ambient temperature for that day.

$$DD = \sum_{h=1}^{24} (T_b - T_a)$$

where only positive terms are included in the summation. To calculate DD for a period of one month or one year we merely sum over all days in the period of interest; the units of DD are °F day.

5.1.8. Building Heat Load (Q_L). The building heat load for a specified period, usually one month or one year, is obtained from the following relation:

$$Q_L = (BLC + G \cdot A_c)DD \quad ,$$

where G is the effective load coefficient of the solar aperture per square foot, and DD is the heating degree days for the time period of interest at the base temperature of the building under consideration. The building heat load is the amount of heat required to hold the building at the thermostat setpoint for the specified time period with an internal source heating rate of Q_{int}.

5.1.9. Load Collector Ratio (LCR). The load collector ratio is the building load coefficient divided by the solar collection area, that is

$$LCR = BLC/A_c \quad .$$

The units of LCR are Btu/°F day ft^2.

5.1.10. Solar Load Ratio (SLR). The solar load ratio is the amount of solar energy absorbed in one month by a passive solar system divided by the building heat load for the same time period. On the basis of previously defined quantities we see that

$$SLR = \frac{S \cdot A_c}{(BLC + G \cdot A_c)DD} \quad ,$$

which may be rearranged as follows:

$$SLR = \frac{(VT/DD)\alpha}{LCR + G} \quad .$$

The solar load ratio is an important parameter in the analysis of passive solar heated buildings. High solar load ratios imply that a relatively large fraction of the building's heat load for that month will be met by solar energy. Conversely, a low solar load ratio means that only a small fraction of the heat load will be met by solar energy.

5.1.11. Auxiliary Heat Requirement (Q_A). The auxiliary heat requirement is the amount of heat that must be supplied by a conventional back-up heating system to maintain the building temperature at T_{set} for a specified time period. We are usually interested in time periods of one month or one year. If a building receives no solar heat, the auxiliary heat requirement

will equal the building heat load. If the entire building heat load is met by solar energy, the auxiliary heat requirement is zero.

5.2. The Fast Solar Load Ratio Method

The fast solar load ratio (FSLR) method, a procedure for obtaining quick, accurate estimates of the annual auxiliary heat requirements of passive solar buildings, is based on the nomogram presented in Fig. 5.1. The yearly heat-to-load ratio $(Q_A/Q_L)_y$, is plotted as a function of the scaled solar load ratio for a series of values of the "a" parameter. The scaled solar load ratio is given by

$$SLR_m^* = F \cdot SLR_m \quad , \tag{5.1}$$

where

$$SLR_m = \frac{VT_m / DD_m \, \alpha}{LCR + G} \tag{5.2}$$

and F, G, and α are tabulated system-dependent parameters.

The subscripts, m, are used to indicate that the parameters are taken for the month of the minimum solar heating fraction; this fact is of no particular concern to the user because the required weather parameter VT_m/DD_m, will be provided in tabular form. So, in order for the user to determine the value of the scaled solar load ratio for his particular design, he has only to calculate the LCR and read the values of all other needed parameters from tables that will be discussed in subsequent sections. The LCR is the building load coefficient divided by the collector area. The collector area is specified by the user (the initial value is determined by the design guidelines in Sec. 4), and the BLC can be calculated quickly by a procedure described in the next section.

After obtaining SLR_m^*, the user must determine the value of the "a" parameter for his particular combination of building site and system. The "a" parameter will be provided in the same tables used for the weather parameter (VT_m/DD_m). Knowing the value of "a," one follows a vertical line upward from SLR_m^* until the appropriate curve is intercepted; some interpolation may be required. A horizontal line is then extended from the intercepted point to the vertical axis where the value of the yearly ratio of auxiliary heat to

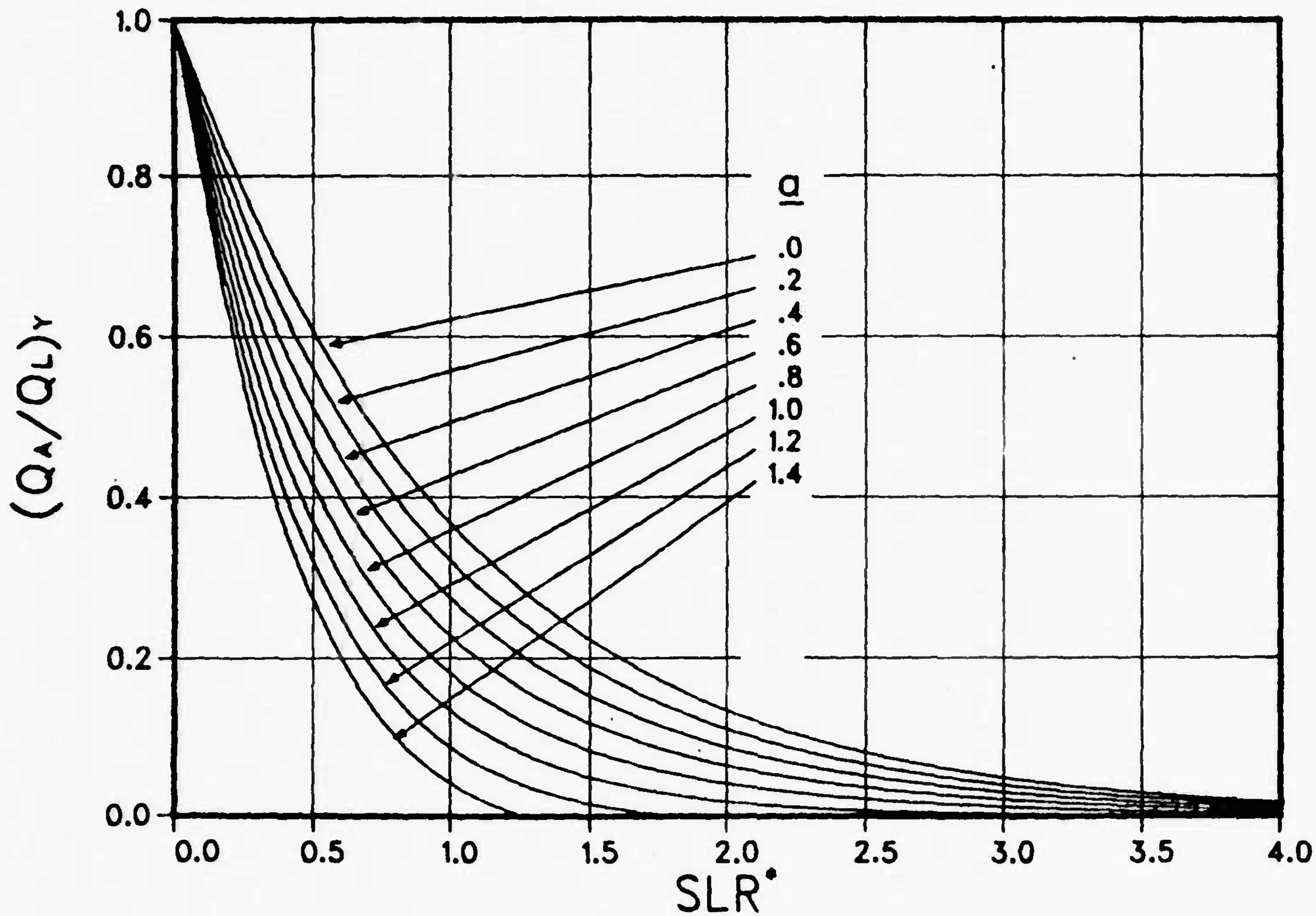

Fig. 5.1. Yearly heat-to-load ratio nomogram.

building load can be read from the scale. One then multiplies this ratio by the yearly building heat load to obtain the auxiliary heat requirement:

$$\left(Q_A\right)_y = \left(\frac{Q_A}{Q_L}\right)_y \cdot \left(Q_L\right)_y \tag{5.3}$$

where

$$\left(Q_L\right)_y = \left(BLC + G \cdot A_c\right) DD_y \tag{5.4}$$

and DD_y is the number of heating degree days for the full one-year period. Values of DD_y are tabulated with the weather data to be discussed later in this chapter.

In summary, the nomogram in Fig. 5.1 can be used to estimate the performance of direct gain and thermal storage wall buildings. The system parameters (F, G, U_c, and α) are provided in tables as are the weather parameters [a, (VT_m/DD_m), and DD_y]. The user calculates the BLC and specifies a value for A_c. After obtaining a value for Q_A, the user may want to consider changing one or more design variables to see what effect the changes have on performance. By continuing this iterative approach, it is possible to fine tune a design to achieve desired cost and performance goals.

5.3. The Building Load Coefficient Worksheet

In this section we present a simple procedure from the DOE Passive Solar Design Handbook[3] for estimating the building load coefficient given certain general information about the building. Whereas this procedure is not intended to replace the detailed American Society for Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) calculations that should be used for the construction-documents phase of design, a careful analyst can generally come within 10% of the ASHRAE method in about ten minutes using the worksheet provided herein. This method is most appropriate for single-family detached residences and small office buildings having single-control zones, but can readily be adapted to larger buildings, as will be discussed at the end of the section.

The procedure consists of adding together several estimated contributions of heat loss. Start by making rough estimates of the combined area of all floors, A_f (ft^2), and the total external perimeter (the combined length

of all external walls of all floors P_t (ft). Then, either estimate the combined area of all east, west, and north windows, or use

$$A_n = \left(P_t \cdot h - A_s\right) NSF \quad ,$$

where A_n is the nonsouth window area, h is the ceiling height, A_s is the total area of the south wall, and NSF is the nonsouth window fraction. The nonsouth window fraction (window area divided by wall area) will normally be between 0.05 for a situation with minimum window area and 0.10 for a case with ample window area. Next, carefully estimate the solar aperture area. Then compute the following:

Walls

$$L_w = 24\ A_w \Big/ \text{RWALL}$$

where the wall area, A_w, is given by

$$A_w = (P_t \cdot h) - A_n - A_c \quad .$$

Nonsouth Window

$$L_n = 26\ A_n \Big/ NGL_n$$

where NGL_n is the number of glazings on nonsouth windows

Perimeter (slab on grade)

$$L_p = 100\ P_g \Big/ (\text{RPERIM} + 5)$$

where P_g is the external perimeter of the ground floor.

Floor (over vented crawl space)

$$L_f = 24\ A_g \Big/ \text{RFLOOR}$$

where A_g is the area of the ground floor.

Basement (heated basement or other fully bermed wall, including floor losses)

$$L_b = 256\ P_g / (RBASE + 8)\ .$$

Note: normally only one L_p, L_f, or L_b will apply.

Roof

$$L_r = 24\ A_r / RROOF$$

where A_r is the area of the roof projected on a horizontal plane and RROOF is the total R-value of the roof structure.

Infiltration

$$L_i = 0.432\ (ACH \cdot ADR \cdot h\ A_f)$$

where ACH is the average number of air changes per hour and ADR is the Air Density Ratio shown in Fig. 5.2 to account for other-than-sea-level locations.

Worksheet No. 2 is designed to help the user obtain an estimate of the BLC after completing the schematic design process outlined on Worksheet No. 1. Worksheet No. 1 defines any parameters needed for but not defined on Worksheet No. 2. Simply fill in the blanks for each contribution, remembering that only one of L_p, L_f, and L_b will apply for floors, and sum the contributions to obtain the total BLC. If the building of interest is a townhouse or a larger building housing more than one control zone, Worksheet No. 2 may still be used to estimate the BLC. Using the BLC for the complete structure will allow one to estimate the appropriate total solar aperture size using procedures presented later in this section. However, one will have to use an approximate procedure to partition the solar aperture among the component control zones of the building, if these control zones have significantly different loss characteristics. A more accurate and more general approach involves calculating the component BLC for each control zone in the structure. In this case, one would use Worksheet No. 2 once for each control zone, bearing in mind the following constraints:

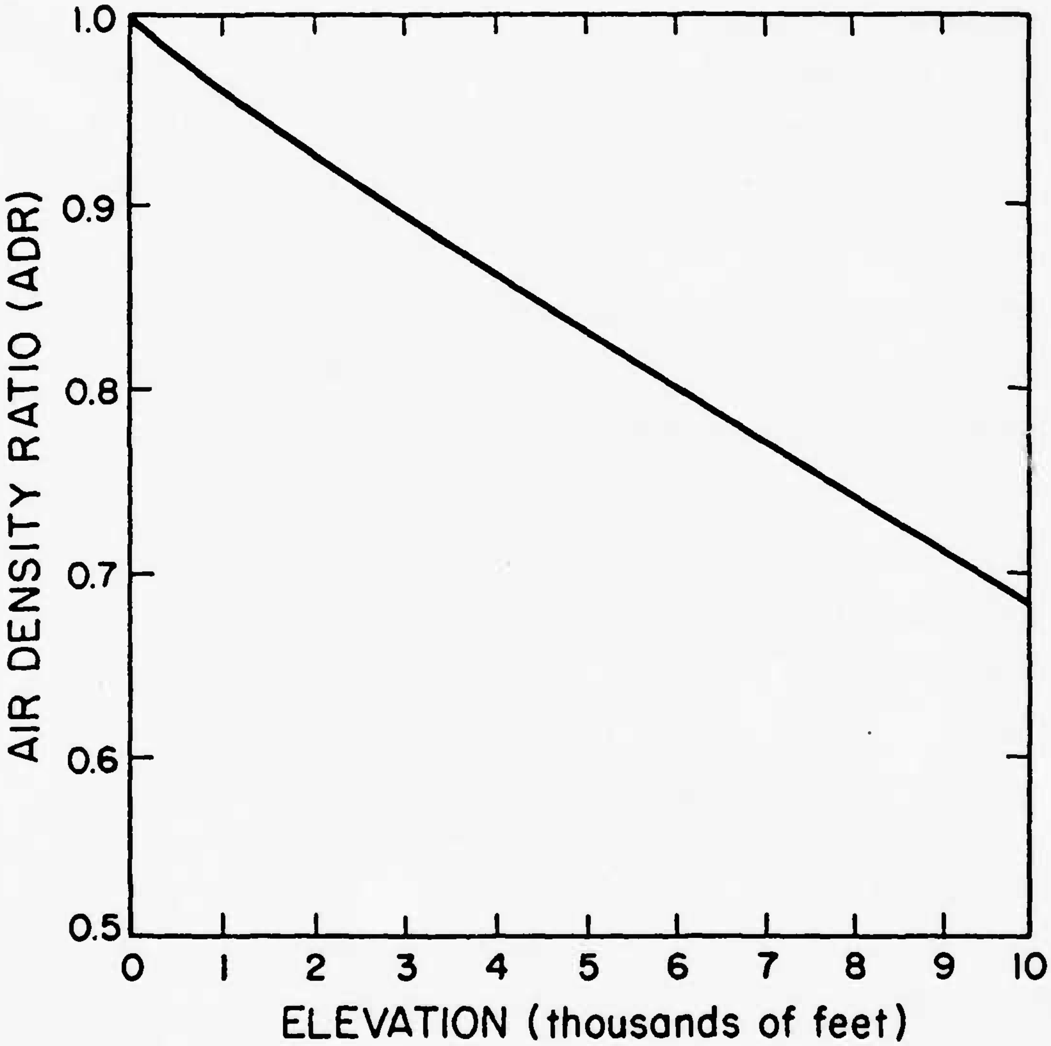

Fig. 5.2. Air-density ratio as a function of elevation.

WORKSHEET NO. 2

ESTIMATION OF BUILDING LOAD COEFFICIENT

Specified Design Parameters

Ground floor perimeter:	P_g = _____	ft
Ground floor area:	A_g = _____	ft^2
Roof area (horizontal projection):	A_r = _____	ft^2
South wall area	A_s = _____	ft^2

Note: A_s includes windows and solar apertures.

Nonsouth window fraction:	NSF = _____	
No. of glazings in nonsouth windows:	NGL_n = _____	
Air changes per hour:	ACH = _____	
Air density ratio (see Fig. 5.2):	ADR = _____	

Calculated Design Parameters

Nonsouth window area:	$A_n = (P_t \cdot h - A_s)NSF$ = _____	ft^2
Wall area:	$A_w = P_t \cdot h - A_c - A_n$ = _____	ft^2

Note: A_w is the total area of all external walls excluding windows and solar apertures.

Building Load Coefficient

Walls:	$L_w = 24\ A_w/RWALL$ = _____	Btu/DD
Nonsouth windows:	$L_n = 26\ A_n/NGL_n$ = _____	Btu/DD
Pick One: Perimeter (slab on grade):	$L_p = 100\ P_g/(RPERIM + 5)$ = _____	Btu/DD
Pick One: Basement (heated):	$L_b = 256\ P_g/(RBASE + 8)$ = _____	Btu/DD
Pick One: Floor (over vented crawl space):	$L_f = 24\ A_g/RFLOOR$ = _____	Btu/DD
Roof:	$L_r = 24\ A_r/RROOF$ = _____	Btu/DD
Infiltration:	$L_i = 0.432 \cdot (ACH\ ADR \cdot h \cdot A_f)$ = _____	Btu/DD
TOTAL:	BLC = _____	Btu/DD

(a) Floors, ceilings, or walls that separate one control zone from another should be excluded from the summation of terms that contribute to the BLC.

(b) The total perimeter of each control zone is calculated as before by taking the combined length of all external walls of all floors. In this case, however, the perimeter of each floor will not necessarily form a closed loop because walls that separate control zones (these walls are always internal) are excluded.

In summary, one may use Worksheet No. 2 to obtain an estimate to the total BLC of any structure or, applying the above constraints, to obtain an estimate of each component BLC for any structure.

5.4. System Correlation Parameters

Tables of system correlation parameters are provided in Appendix A for 109 passive solar designs. The task of the user is to select those parameters that most closely represent his own design; guidance for this selection process is provided in the following subsections.

5.4.1. Direct Gain Buildings. Correlation parameters are provided in Appendix A for a set of 81 direct gain systems. The set of 81 systems was defined by selecting three appropriate values for each of the four principal design variables and allowing all possible combinations of those variables (Note: 3 x 3 x 3 x 3 = 81 combinations). The principal design variables and associated values are

A_m/A_c = 3, 6, 9
THICK = 2, 4, 6 (in.)
RVALUE = 0, 4, 9 (h°F ft^2/Btu)
NGL = 1, 2, 3.

Where A_m/A_c is the ratio of the mass surface area to the solar-collection area, THICK is the thickness of the thermal storage mass in inches, RVALUE is the R-value of night insulation, and NGL is the number of glazing layers in the aperture. For the direct gain designs the product of density, specific heat, and thermal conductivity (ρck) is fixed at 30 Btu^2/h ft^4•F^2.

Values of the correlation parameters, F and G, the steady-state aperture conductance, U_c, and the effective solar absorptance, α, for each of the 81 reference designs can be found in Appendix A. The system-numbering procedure

described at the beginning of the parameter tabulations should enable the user to easily locate the appropriate system.

A complete description of the properties of the direct gain, Trombe wall, and water wall reference designs is presented in Table 5.1. These properties all affect the performance of the building and, consequently, the value of the correlation parameters. However, the user has the option to vary only the four principal parameters described above in addition to the orientation, the thermostat setpoint, and the rate of internal-source heating. Procedures for varying the latter three parameters will be described later in this chapter.

5.4.2. Trombe Walls. Also presented in Appendix A are correlation parameters for nine vented Trombe walls and for nine corresponding unvented Trombe walls. The design options include double-glazed systems with no night insulation at thicknesses of 6 in., 12 in., and 18 in. with a ρck product of either 15 $Btu^2/h\ ft^4{\cdot}F^2$ or 30 $Btu^2/h\ ft^4{\cdot}F^2$. For the 12 in. wall with ρck = 30, one may also select a single-glazed system with or without R9 night insulation or a double-glazed system with R9 night insulation. The characteristics of the reference Trombe wall designs are presented in Table 5.1.

5.4.3. Water Walls. Appendix A contains correlation parameters for six water wall systems. Double-glazed systems with no night insulation are allowed in equivalent thicknesses of 6 in., 9 in., and 12 in. The equivalent thickness is the volume of water provided for thermal storage divided by the solar-collection area. The additional options allowed for a 9-in. wall are single-glazed systems with or without R9 night insulation and double-glazed systems with R9 night insulation. All other system characteristics are given in Table 5.1.

5.4.4. Concrete Block Walls. Four correlations for thermal storage walls constructed of 8 in. x 8 in. x 16 in. concrete building blocks are presented in Appendix A. These correlations should be particularly useful for retrofit applications involving concrete-block buildings. The concrete blocks used to develop the correlations had two hollow rectangular cores and weighed about 25 lb. each. The four correlations provided include single- and double-glazed systems with and without mortar filling in the cores. Other characteristics of the reference designs are given in Table 5.1.

5.4.5. Mixed Systems. The correlation parameters for mixed systems are obtained simply by area-weighting the parameters of the component systems.

TABLE 5.1

REFERENCE DESIGN CHARACTERISTICS

Masonry properties (direct gain and Trombe wall)	ρck = 15	ρck = 30
thermal conductivity (k)	0.6 Btu/h ft F	1.0 Btu/h ft °F
density (ρ)	125 lb/ft^2	150 lb/ft^3
specific heat (c)	0.2 Btu/lb F	0.2 Btu/lb °F
Solar absorptance of thermal storage mass		
water wall		0.95
Trombe wall and concrete-block wall		0.95
direct gain		0.8
Infrared emittances of thermal storage mass		0.9
Glazing properties		
transmission characteristics		diffuse
orientation		due south
index of refraction		1.526
extinction coefficient		0.5 in.$^{-1}$
thickness of each pane		1/8 in.
air gap between panes		1/2 in.
Control range		
room temperature		65°F to 75°F
internal heat generation		0
Thermocirculation vents (vented Trombe walls)		
(when used)		
vent area/Trombe wall area (sum of both upper and lower vents)		0.06
height between vents		8 ft
reverse flow		none
Night insulation		
(when used)		
thermal resistance (thermal storage walls)		R9
thermal resistance (direct gain)		R4 or R9
in place, solar time		5:30 PM - 7:30 AM
Solar radiation assumptions		
shading		none
ground diffuse reflectance		0.3

Ordinarily, no more than two distinct passive solar systems will appear on a single building. A common and useful combination is a mixture of direct gain and thermal storage wall systems that provides daylighting, a view, quick warm-up in the morning and delayed heat delivery in the evening.

5.4.6. The System Parameter Worksheet. Worksheet No. 3 is provided to help the user keep track of the various system parameters obtained from Appendix A and to clarify and organize the calculation of parameters for mixed systems. Mixtures of two system types only are allowed on the worksheet. The procedure could be generalized to allow for combinations of three or more systems, but the infrequent occurrence of such combinations does not warrant complicating the worksheet.

5.5. Weather Parameters

Having determined the BLC in Sec. 5.3 and the system parameters (F, G, U_c, and α) in Sec. 5.4, we now turn to evaluation of the weather parameters that are needed for application of the FSLR method. The required parameters are the transmitted radiation-to-degree-day ratio, VT/DD, and the city parameter, "a", which are provided for each of 209 cities within the continental United States in Appendix B. Provision is made for obtaining parameter values for single-, double-, or triple-glazed systems, operating at base temperatures, ranging from 40° to 70°F and departing from true south by up to 60° to the east or west. Use of the tables in Appendix B is discussed in the following subsections.

5.5.1. Transmitted-Radiation-to-Degree-Day Ratio. The user should first locate the city of interest in Appendix B. The various locations are alphabetized, first by state and second by city within each state. Next, calculate the base temperature as discussed in Sec. 5.1.6:

$$T_b = T_{set} - Q_{int}/(BLC + 24\ U_c \cdot A_c).$$

Now, locate the column with the appropriate value of the base or reference temperature, TR. Reference temperature ranging from 40 to 70°F in increments of 5°F are provided; interpolation may be required. Having located the correct column, read and record the value from the row labeled VT1/DD, VT2/DD, or VT3/DD, depending on whether the system of interest is single-, double-, or triple-glazed, respectively.

WORKSHEET NO. 3

SYSTEM PARAMETERS

First System

System Type: ______

System No: ______

Scale factor: F_1 = ______

Effective aperture conductance (daily): G_1 = ______ Btu/°F day ft^2

Steady-state aperture conductance (hourly) U_{c1} = ______ Btu/°F h ft^2

System solar absorptance: α_1 = ______

Collection aperture area: A_{c1} = ______ ft^2

Second System

System Type: ______

System No: ______

Scale factor: F_2 = ______

Effective aperture conductance (daily): G_2 = ______ Btu/°F day ft^2

Steady-state aperture conductance (hourly): U_{c2} = ______ Btu/°F h ft^2

System solar absorptance: α_2 = ______

Collection aperture area: A_{c2} = ______ ft^2

First System Area Fraction

$f_1 = A_{c1}/(A_{c1} + A_{c2})$

Second System Area Fraction

$f_2 = A_{c2}/(A_{c1} + A_{c2})$

Mixed System Parameters

Scale factor: $F = f_1 \cdot F_1 + f_2 \cdot F_2 =$ ______

Effective aperture conductance (daily): $G = f_1 \cdot G_1 + f_2 \cdot G_2 =$ ______ Btu/°F day ft^2

Steady-state aperture conductance (hourly): $U_c = f_1 \cdot U_{c1} + f_2 \cdot U_{c2} =$ ______ Btu/°F h ft^2

System solar absorptance: $\alpha = f_1 \cdot \alpha_1 + f_2 \cdot \alpha_2 =$ ______

Collection aperture area: $A_c = A_{c1} + A_{c2} =$ ______ ft^2

For mixed systems with different numbers of glazings, calculate an area-weighted glazing number as follows:

$$NGL = f_1 \cdot NGL_1 + f_2 \cdot NGL_2.$$

The ratio VT/DD is then obtained by interpolating vertically between the appropriate integral values in the table. A procedure for adjusting the VT/DD ratio for an off-south orientation will be discussed in Sec. 5.5.3.

5.5.2. The City Parameter. The city parameter, "a", is obtained from the same column in which VT/DD was found; again, interpolation may be required. The number is read from the row marked "PARAMETER A" under the set of values indicated for "DUE SOUTH" orientation. The adjustment required for off-south orientations is discussed in the next section.

5.5.3. Off-south Orientations. If the orientation of the solar-collection aperture is not due south, the weather parameters must be corrected as follows:

$$VT/DD = (VT/DD)_0 \left(1 + \frac{B_1 \cdot \theta}{1000} + \frac{B_2 \cdot \theta^2}{1000}\right) , \tag{5.1}$$

$$a = a_0 \left(1 + \frac{C_1 \cdot \theta}{1000} + \frac{C_2 \cdot \theta^2}{1000}\right) , \tag{5.2}$$

where $(VT/DD)_0$ and a_0 are the due south values of the weather parameters, VT/DD and "a" are the corrected values, and θ is the azimuth of the collector in degrees, with due south taken as zero and east as positive. The coefficients, B_1, B_2, C_1, and C_2 are read from the same base-temperature column that yielded due south values of the weather parameters. The corrections given above are quite accurate for off-south orientations of up to $\pm$ 60°.

5.5.4. The Weather Parameter Worksheet. Worksheet No. 4 is provided to allow the user to record building location and system data that determine where in Appendix B to find appropriate values for the weather parameters, VT/DD and "a". The worksheet also allows the user to record the values of the weather parameters obtained for a due south orientation and to correct those values should the system be otherwise oriented. It is assumed that the components of mixed systems have identical orientations.

A blank is also provided on Worksheet No. 4 for recording DD_y, the yearly heating degree days at the base temperature of interest. This number is obtained from Appendix B on the row labeled "ANNUAL DD" in the column for the appropriate base or reference temperature.

5.6. The Auxiliary-Heat-Consumption Worksheet

Estimation of auxiliary heat requirements is addressed on Worksheet No. 5. First, the scaled solar load ratio of the system is calculated on the basis of parameters previously recorded on Worksheets 2, 3, and 4. Then the yearly heat-to-load ratio is read off the nomogram in Fig. 5.1 using the calculated value of the scaled solar load ratio and the city parameter recorded on Worksheet No. 4. Finally, the auxiliary heat required annually is obtained by multiplying the heat-to-load ratio by the annual building load. Worksheet No. 5 guides the user through the calculation and provides a written record of the bottom-line results of the design analysis.

WORKSHEET NO. 4

WEATHER PARAMETERS

Location and System Data

State: ______________

City: ______________

Thermostat setpoint: T_{set} = ______________ °F

Internal heat generation rate Q_{int} = ______________ Btu/day

Base temperature: $T_b = T_{set} - Q_{int}/(BLC + 24\ U_c \cdot A_c)$ = ______________ °F

Number of glazings on first solar aperture: NGL_1 = ______________

Number of glazings on second solar aperture: NGL_2 = ______________

Area-weighted system glazing no.: $NGL = f_1 \cdot NGL_1 + f_2 \cdot NGL_2$ = __________

Weather Parameters for Due South Orientation

Transmitted-radiation-to-degree-day ratio: $(VT/DD)_o$ = __________ Btu/ft^2 DD

City parameter: a_o = __________

Correction for Off-South Orientation

Azimuth: θ = __________ degrees

Coefficients: B_1 = ______ B_2 = ______

C_1 = ______ C_2 = ______

Corrected transmitted-radiation-to-degree-day ratio:

$$VT/DD = (VT/DD)_o \left(1 + \frac{B_1 \cdot \theta}{1000} + \frac{B_2 \cdot \theta^2}{1000}\right)$$ = ______ Btu/ft^2°F day

Corrected city parameter:

$$a = a_o \left(1 + \frac{C_1 \cdot \theta}{1000} + \frac{C_2 \cdot \theta^2}{1000}\right)$$ = __________

Annual Heating Degree Days:

DD_y = ________ °F day

WORKSHEET NO. 5

ESTIMATION OF AUXILIARY HEAT CONSUMPTION

The Scaled Solar Load Ratio

$$SLR^* = \frac{F(VT/DD)\alpha}{BLC/A_c + G} \qquad = \_\_\_\_\_\_\_\_\_\_\_\_$$

Note: All parameters in this expression are defined and recorded on Worksheets 2, 3, and 4.

The Yearly Heat-to-Load Ratio

$$(Q_A/Q_L)_y \qquad = \_\_\_\_\_\_\_\_\_\_\_\_$$

Note: The yearly heat-to-load ratio is obtained from the nomogram in Fig. 5.1. Using the value of SLR^* calculated above and the city parameter "a" from Worksheet No. 4, one simply reads the heat-to-load ratio off the vertical axis of the nomogram.

Yearly Auxiliary Heat Requirement

$$Q_A = (Q_A/Q_L)_y\,(BLC + G \cdot A_c)DD_y \qquad = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ Btu}$$

6. SAMPLE CALCULATION FOR A FOUR-PLEX FAMILY HOUSING UNIT

6.1. Description of the Building

In this section we present an example that illustrates the use of the rules of thumb provided in Chap. 4 and the design-analysis procedures discussed in Chap. 5. To fully exercise the design method, we consider a four-plex family housing unit that employs a direct gain system to provide solar heat for the occupants.

An orthogonal projection of the four-plex unit we shall solarize is presented in Fig. 6.1. The long dimension of the structure is oriented 15° east of true south, the departure resulting presumably from some constraint at the building site. Each individual two-story family section has a length of 37 ft and a depth of 23 ft. Thus, the heated floor space of each section is about 1700 ft^2 and the total floor space of the structure is 6800 ft^2.

6.2. Schematic Design Parameters

Now, let us assume the four-plex housing unit is to be located in Norfolk, Virginia, and proceed with schematic design of the conservation and passive solar features. We begin by filling out Worksheet No. 1, as indicated in Table 6.1. Using the dimensions given in Fig. 6.1 and the formulas on Worksheet No. 1, one easily calculates the "Building Size" parameters and obtains an external surface-area-to-floor-area ratio of 2.91. Note that we are employing the total floor space of the four-plex unit and will, therefore, obtain the total aperture size and auxiliary-heat requirement for the building as the results of our analysis. (Later we shall suggest an approximate procedure for partitioning the aperture area between inner and outer sections. We shall also discuss a section-by-section analysis.)

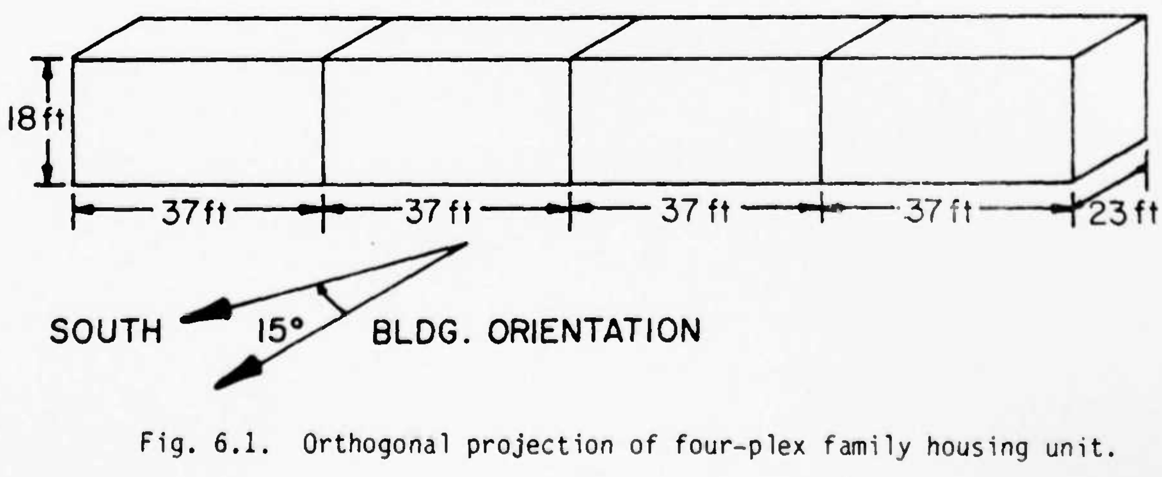

Fig. 6.1. Orthogonal projection of four-plex family housing unit.

TABLE 6.1

WORKSHEET NO. 1 FOR NORFOLK, VIRGINIA, FOUR-PLEX UNIT

SCHEMATIC DESIGN PARAMETERS

Building Size

Heated floor space: A_f = 6800 ft^2

Ceiling height: h = 9 ft

Total external perimeter: P_t = 684 ft

Note: Include external perimeter of each floor.

External surface area: $A_e = 2A_f + h \cdot P_t$ = 19,756

External surface area-to-floor-area ratio: A_e/A_f = 2.91

Insulation Levels

$RWALL_o$ = 22 ft^2 °F h/Btu

Note: $RWALL_o$ is obtained from the contour map in Fig. 3.1 and the insulation levels recommended in Sec. 4.4.

$RWALL = \frac{1}{3}\left(\frac{A_e}{A_f}\right) RWALL_o$ = 21 ft °F h/Btu

RROOF = 1.5 RWALL = 32 ft^2 °F h/Btu

RPERIM or RBASE = .75 RWALL = 16 ft^2 °F h/Btu

Solar Aperture Size (Due South Orientation)

$\left(\frac{A_c}{A_f}\right)_o$ = 0.12

Note: $\left(\frac{A_c}{A_f}\right)_o$ is obtained from the contour map in Fig. 4.1. Remember to convert from per cent to the fractional value before recording the quantity.

$A_c = A_f \left(\frac{A_c}{A_f}\right)_o \left(\frac{A_e}{A_f}\right) \Big/ 3$ = 791 ft^2

Building Orientation (Azimuth): θ = 15 degrees

Note: Azimuth is zero for due south and positive to the east

Solar Aperture Size (Corrected for Off-South Orientation)

$A_c = \left(A_c\right)_{south} \left[\cos\left(\frac{4}{5}\theta\right)\right]$ = 774 ft^2

Next, we select a reference value for the wall insulation, $RWALL_0$, from the contour map in Fig. 3.1 and the ranges recommended in Sec. 4.4. As Norfolk is slightly below the middle of the harsh climate range on the east coast, an R-value just below the middle of the recommended range is selected, that is, $RWALL_0 = 22$; after correcting for building size, RWALL becomes 21. Values for roof and perimeter insulation are easily obtained from the scaling formulas indicated on the worksheet.

The aperture-size ratio (expressed in per cent of floor space) for a reference 1500 ft^2 building is read from the contour map in Fig. 4.1. Selecting the maximum value for the region encompassing Norfolk, we obtain

$$\left(\frac{A_c}{A_f}\right)_o = 0.12 \quad ,$$

where we have indicated the fractional value rather than per cent. This ratio is then scaled for building size (using the formula on the worksheet) to obtain a total solar collection area of

$$A_c = 791 \text{ ft}^2 \quad .$$

This area is further reduced by the azimuth-correction formula that seeks to hold the aperture productivity at a near constant value. Correcting for the 15° east orientation yields

$$A_c = 774 \text{ ft}^2 \quad .$$

The solar-collection area calculation completes the schematic phase of conservation and solar design. We now move on to Worksheet No. 2 and calculate the building load coefficient in preparation for analysis of the building heating requirements.

6.3. The Building Load Coefficient

A copy of Worksheet No. 2 is provided in Table 6.2. The ground floor perimeter of the four-plex unit is half the total value, or 342 ft. The ground floor and roof area are equal at 3404 ft^2 and the total south-wall area is 266 ft^2. We have assumed a nonsouth window fraction, NSF, of 0.05

TABLE 6.2

WORKSHEET NO. 2 FOR NORFOLK, VIRGINIA FOUR-PLEX UNIT

ESTIMATION OF BUILDING LOAD COEFFICIENT

Specified Design Parameters

Ground floor perimeter:	P_g	= 342	ft
Ground floor area:	A_g	= 3404	ft^2
Roof area (horizontal projection):	A_r	= 3404	ft^2
South wall area	A_s	= 2664	ft^2

Note: A_s includes windows and solar apertures.

Nonsouth window fraction:	NSF	= 0.05	
No. of glazings in nonsouth windows:	NGL_n	= 2	
Air changes per hour:	ACH	= 0.6	
Air density ratio (see Fig. 5.2):	ADR	= 1.0	

Calculated Design Parameters

Nonsouth window area:	$A_n = (P_t \cdot h - A_s)NSF$	= 175	ft^2
Wall area:	$A_w = P_t \cdot h - A_c - A_n$	= 5207	ft^2

Note: A_w is the total area of all external walls excluding windows and solar apertures.

Building Load Coefficient

Walls:		$L_w = 24\ A_w/RWALL$	= 5951	Btu/DD
Nonsouth windows:		$L_n = 26\ A_n/NGL_n$	= 2275	Btu/DD
Pick One	Perimeter (slab on grade):	$L_p = 100\ P_g/(RPERIM + 5)$	= 1629	Btu/DD
	Basement (heated):	$L_b = 256\ P_g/(RBASE + 8)$	=	Btu/DD
	Floor (over vented crawl space):	$L_f = 24\ A_g/RFLOOR$	=	Btu/DD
Roof:		$L_r = 24\ A_r/RROOF$	= 2553	Btu/DD
Infiltration:		$L_i = 0.432\ (ACH \cdot ADR \cdot h \cdot A_f)$	= 15863	Btu/DD
TOTAL:		BLC	= 28271	Btu/DD

and double glazing on all windows. The infiltration rate is set at 0.6 air changes per hour and the air-density ratio at the near-sea-level building site is 1.0.

In the next section of the worksheet we calculate a nonsouth window area of 175 ft^2 and a wall area (excluding south and nonsouth windows) of 5207 ft^2.

In the final section of Worksheet No. 2 we simply compute the various contributions to the BLC using the indicated formulas and parameter values found on this and the preceding worksheet. The contributions are summed at the bottom of the sheet to obtain a building load coefficient of 28,271 Btu/DD.

6.4. The System Parameters

Next, the system parameters are recorded on Worksheet No. 3, which is reproduced as Table 6.3 for this example. We have already selected a direct gain system and turn, therefore, to the first set of system correlation parameters in Appendix A. Study the system-numbering convention. The first digit gives the ratio of the thermal-storage-mass surface area to the area of the direct gain aperture. If we assume that both upper and lower floors are 4-in.-thick concrete slab but that only three fourths of this mass is available for thermal storage, then the mass surface area is $A_m = 5100\ ft^2$. To be "available" for thermal storage, the concrete must be essentially uninsulated on the side that faces a direct gain zone; in other words, the slab must not be carpeted. A good rule of thumb is that the R-value of any decorative floor or wall covering on massive surfaces should not exceed 0.5 h°F ft^2/Btu. A second rule of thumb is to count only half of the thermal mass not located in direct gain zones as available for thermal storage and then only if the zone in question is convectively coupled (as by a forced-air distribution system or by large doorways) to a direct gain zone.

Now, we have already obtained an initial value of 774 ft^2 for the area of the direct gain aperture. This value was recorded on the first worksheet. The mass-area-to-glazing-area ratio is, therefore, given by

$$A_m/A_g = 5100/774 = 6.59 \quad .$$

The closest available reference value for direct gain systems in Appendix A is 6, so we select that value as the first digit in the system number. We have already assumed that the floor slab thickness is 4 in., so the second digit in

TABLE 6.3

WORKSHEET No. 3 FOR NORFOLK, VIRGINIA, FOUR-PLEX UNIT

SYSTEM PARAMETERS

First System

System Type:		direct gain	
System No:		6442	
Scale factor:	F_1 =	0.966	
Effective aperture conductance (daily):	G_1 =	4.08	Btu/°F day ft^2
Steady-state aperture conductance (hourly):	U_{c1} =	0.35	Btu/°F h ft^2
System solar absorptance:	α_1 =	0.97	
Collection aperture area:	A_{c1} =	774	ft^2

Second System

System Type:		______	
System No:		______	
Scale factor:	F_2	______	
Effective aperture conductance (daily):	G_2 =	______	Btu/°F day ft^2
Steady-state aperture conductance (hourly):	U_{c2} =	______	Btu/°F h ft^2
System solar absorptance:	α_2 =	______	
Collection aperture area:	A_{c2} =	______	ft^2

First System Area Fraction

$f_1 = A_{c1}/(A_{c1} + A_{c2})$ f_1 = ______

Second System Area Fraction

$f_2 = A_{c2}/(A_{c1} + A_{c2})$ f_2 = ______

Mixed-System Parameters

Scale factor:	$F = f_1 F_1 + f_2 F_2$	= ______	
Effective aperture conductance (daily):	$G = f_1 G_1 + f_2 G_2$	= ______	Btu/°F day ft^2
Steady-state aperture conductance (hourly):	$U_{c2} = f_1 U_{c1} + f_2 U_{c2}$	= ______	Btu/°F h ft^2
System solar absorptance:	$\alpha = f_1 \alpha_1 + f_2 \alpha_2$	= ______	
Collection aperture area:	$A_c = A_{c1} + A_{c2}$	= ______	ft^2

the system number is 4. Finally, selecting a night-insulated system with an R-value of 4 h °F ft^2/Btu and two glazing layers, we obtain a system number of 6442 and record that value at the top of Worksheet No. 3. Next, we complete the worksheet by locating system No. 6442 in Appendix A and recording the indicated values for F, G, U_c, and α in the blanks provided. The aperture area, 774 ft^2, is also recorded to facilitate analysis of mixed systems.

In some instances we might decide to mix two different system types, and Worksheet No. 3 allows for this possibility. To treat a mixed system, repeat the above procedure for the second system and enter the component areas in the indicated blanks. The mixed-system parameters are then calculated using the weighting procedure indicated on the worksheet.

6.5. The Weather Parameters

Weather parameters are entered on Worksheet No. 4, which is reproduced in Table 6.4 for this sample calculation. Weather data in Appendix B is alphabetized, first by state and second by city within each state. The first two entries in Worksheet No. 4 are, therefore, the state, Virginia, and the city, Norfolk. Next, enter the thermostat setpoint that is assumed to be 68°F. The internal-heat-generation rate, Q_{int}, is determined as the product of 20,000 Btu per person per day (a typical value) and 14, the probable average number of occupants of a quadruplex (assuming an average family size of 3.5 persons). The base temperature of 60°F is then calculated from the indicated formula. The next three entries on the worksheet indicate a single solar system type with a double-glazed aperture.

Finally, turn to the weather data for Norfolk, Virginia, in Appendix B. The desired value of the transmitted-radiation-to-degree-day ratio is obtained from the column marked TR65 (indicating a base temperature of 65°F) and the row labeled VT2/DD (indicating a double-glazed system).

A value of

$$(VT/DD)_o = 27.44 \text{ BTU/ft}^2$$

is read from the table. The subscript, o, indicates a due south orientation. Similarly, from the same column and the row marked "PARAMETER A" we obtain

$$a_o = 0.637$$

for a southern orientation.

TABLE 6.4

WORKSHEET NO. 4 FOR NORFOLK, VIRGINIA, FOUR-PLEX UNIT

WEATHER PARAMETERS

Location and System Data

State: Virginia

City: Norfolk

Thermostat setpoint: T_{set} = 68 °F

Internal heat generation rate Q_{int} = 2.8×10^5 Btu/day

Base temperature: $T_b = T_{set} - Q_{int}/(BLC + 24\, U_c \cdot A_c)$ = 60 °F

Number of glazings on first solar aperture: NGL_1 = 2

Number of glazings on second solar aperture: NGL_2 = ---

Area-weighted system glazing no.: $NGL = f_1 \cdot NGL_1 + f_2 \cdot NGL_2$ = 2

Weather Parameters for Due South Orientation

Transmitted-radiation-to-degree-day ratio: $(VT/DD)_o$ = 27.44 Btu/ft^2 DD

City parameter: a_o = 0.637

Correction for Off-South Orientation

Azimuth: = 15 degrees

Coefficients: B_1 = 0.990 B_2 = -0.073

C_1 = -2.124 C_2 = -0.040

Corrected transmitted-radiation-to-degree-day ratio:

$$VT/DD = (VT/DD)_o \left(1 + \frac{B_1 \cdot \theta}{1000} + \frac{B_2 \cdot \theta^2}{1000}\right) = 27.40 \text{ Btu/ft}^2 \text{ °F day}$$

Corrected city parameter:

$$a = a_o \left(1 + \frac{C_1 \cdot \theta}{1000} + \frac{C_2 \cdot \theta^2}{1000}\right) = 0.611$$

Annual Heating Degree Days:

DD_y = 2778 °F day

To correct for the azimuth of 15° east, one simply records the values of B_1, B_2, C_1, and C_2 from the TR60 column and performs the indicated calculations. Note that for an azimuth of 15° off-south, the corrections are very small; as a general rule, the corrections will not usually be significant until the azimuth approaches $\pm$ 30° off-south. Finally, before leaving Worksheet No. 4, the annual heating degree days for a base temperature of 60°F is recorded as indicated.

6.6. Auxiliary Heat Requirements

The auxiliary heat requirements of the building are calculated using Worksheet No. 5, which is reproduced in Table 6.5 for our four-plex example. The scaled solar load ratio, SLR^*, is computed from parameters previously recorded on other worksheets and found to be 0.63. Using this value and the city parameter, "a", from Worksheet No. 4, the yearly heat-to-load ratio is read from the nomogram in Fig. 5.1 as 0.37. Finally, using the formula at the bottom of the worksheet, we calculate an annual auxiliary-heat requirement of 32.3 MMBtu for the four-plex unit. Dividing this figure by the floor space of 6800 ft^2 and the annual heating degree days of 2778 yields an auxiliary heating factor of 1.71 Btu/ft^2 DD.

6.7 Distribution of the Solar Aperture

In general, the total solar aperture of a multifamily unit should be distributed in a manner that provides greater solar gains to the sections of the unit that experience the greater loads. We can accomplish this by performing the calculations presented in the preceding five sections once for each unique thermal zone within a unit. The worksheets are set up to allow this procedure by entering appropriate values for the heated floor space and using the specialized definition of total perimeter, P_t, that excludes partitions between distinct thermal zones. However, in many cases the much simpler procedure described below is adequate.

On Worksheet No. 2 we determined that the four-plex unit has a total BLC of 28,271 Btu/DD. Each of the four sections, therefore, has, on the average, a BLC of 7068 Btu/DD, or one fourth of the total value. The average BLC value must be adjusted to account for the different loss characteristics of the two unique thermal zones that exist in the four-plex units. The two outer sections will clearly have a larger loss coefficient than the two interior sections that have two shared or common side walls. It is assumed that a negligible amount of heat is transferred through these common walls because

TABLE 6.5

WORKSHEET NO. 5 FOR NORFOLK, VIRGINIA, FOUR-PLEX UNIT

ESTIMATION OF AUXILIARY HEAT CONSUMPTION

The Scaled Solar Load Ratio

$SLR^* = \frac{F(VT/DD)\alpha}{BLC/A_c + G}$ = 0.63

Note: All parameters in this expression are defined and recorded on Worksheets 2, 3, and 4.

The Yearly Heat-to-Load Ratio

$(Q_A/Q_L)_y$ = 0.37

Note: The yearly heat-to-load ratio is obtained from the nomogram in Fig. 5.1. Using the value of SLR^* calculated above and the city parameter "a" from Worksheet No. 4, one simply reads the heat-to-load ratio off the vertical axis of the nomogram.

Yearly Auxiliary Heat Requirement

$Q_A = (Q_A/Q_L)_y\ (BLC + G \cdot A_c)DD_y$ = 32.3×10^6 Btu

only small temperature differences are likely to exist from one side to the other. The exterior side walls on the end sections, however, lose heat to ambient conditions that may be quite cold.

We can easily calculate the loss characteristics of the end walls from the equations on Worksheet No. 2. The nonsouth window area becomes

$$A_n = (P_t \cdot h - A_s)NSF = (2 \times 23 \times 9 - 0).05 = 21 \text{ ft}^2 \quad ,$$

and the end-wall area is given by

$$A_w = (P_t \cdot h - A_c - A_n) = (2 \times 23 \times 9 - 0 - 21) = 393 \text{ ft}^2 \quad .$$

Note that for both calculations we simply take the perimeter to be the length of the end wall (including both floors) and set the south-wall area to zero. This procedure is equivalent to analyzing a thermal zone that has zero thickness.

Now, the load coefficient of the wall is given by

$$L_w = 24\ A_w/RWALL = 24 \times 393/21 = 449 \text{ Btu/DD} \quad ,$$

and the window contribution is

$$L_n = 26\ A_n/NGL_n = 26 \times 21/2 = 273.$$

These two components yield a total load coefficient of 722 for the end wall. The average load coefficient of the four sections may be adjusted as follows to obtain individual BLC values for interior and exterior sections:

$$BLC_i = BLC_{ave} - \frac{722}{2} \quad ,$$

$$BLC_e = BLC_{ave} + \frac{722}{2} \quad ,$$

where the subscript, i, refers to the interior section and the subscript, e, refers to the exterior section.

Carrying out the computation yields

$BLC_i = 6707$ Btu/DD ,

$BLC_e = 7429$ Btu/DD ,

Equating the load collector ratios of the interior and exterior sections yields

$$\frac{BLC_i}{A_{ci}} = \frac{BLC_e}{A_{ce}} \quad ,$$

or

$$A_{ce} = \frac{BLC_e}{BLC_i} A_{ci} \quad ,$$

which yields $A_{ce} = 1.11\ A_{ci}$.

The sum of the solar collection area for one interior and one exterior section is half the total for the unit, or

$$A_{ce} + A_{ci} = \frac{774}{2} = 387 \quad .$$

Substituting the equation for A_{ce} into the above relation yields

$$1.11\ A_{ci} + A_{ci} = 387 \quad ,$$

or

$$2.11\ A_{ci} = 387 \quad ,$$

which finally gives us

$$A_{ci} = 183\ \text{ft}^2$$

for the solar aperture area of interior sections. The aperture area of exterior sections is given by

$$A_{ce} = 1.11\ A_{ci} \quad ,$$

or

$$A_{ce} = 204\ \text{ft}^2 \quad .$$

Note that the aperture sizes differ by only about 10% and that one could perform the sizing with reasonable accuracy (for this example) by simply

distributing the total aperture area (774 ft^2) uniformly among the sections. In that case, one obtains

$$A_{c_{ave}} = \frac{774}{4} ,$$

or

$$A_{c_{ave}} = 194 \text{ ft}^2$$

as the average solar aperture size for the four sections.

6.8. Fine Tuning the Design

Now that we have completed a base line analysis of the family housing unit using design parameter values obtained from the schematic-design guidelines presented in Chap. 4, we are in a position to fine tune the design. Is the annual heating requirement still too high? Increasing the insulation level, increasing the size of the solar aperture or changing to another passive system that offers better performance will all reduce auxiliary-heat consumption. Does thermal performance of the building exceed project goals at the expense of an unacceptable high initial cost? The initial cost can generally be reduced by compromising the thermal performance with a less effective passive heating system. In any case, the effect of a modification to the initial design can be assessed by repeating the analysis on each of the five worksheets affected by the modification. One may wish to evaluate a series of possible design variations in this manner.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to Charles Miles and Ed Durlak for providing us the opportunity to be involved in the task of improving the energy efficiency of buildings at US Navy installations. We feel quite strongly that the military may provide the proving ground for applied passive solar technology and thereby lead the commercial sector out of the stagnation that has characterized building design during the past decade. Mr. Miles and Mr. Durlak are well acquainted with energy-efficient building technology. Their guidance and direction has been most valuable.

Much of the material presented herein was adapted from work performed by other members of the Los Alamos Solar Energy Group under the support of the United Stated Department of Energy. Individuals who contributed original material are Doug Balcomb, Robert Jones, Gloria Lazarus, and Bob McFarland.

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APPENDIX A

SYSTEM PERFORMANCE CORRELATION PARAMETERS

DIRECT GAIN SYSTEMS

System-Numbering Convention

First digit: Mass-area-to-glazing-area ratio (3, 6, or 9)

Second digit: Mass thickness in inches (2, 4, or 6)

Third digit: R-value of night insulation (0, 4, or 9)

Fourth digit: Number of glazings (1, 2, or 3)

System No. (ascending order)	F	G	U_c	α
3201	0.458	22.56	1.10	0.94
3202	0.576	10.32	0.49	0.94
3203	0.661	6.48	0.31	0.94
3241	0.608	9.60	0.61	0.94
3242	0.623	5.04	0.35	0.94
3243	0.669	3.36	0.28	0.94
3291	0.637	8.16	0.53	0.94
3292	0.651	3.60	0.27	0.94
3293	0.685	2.16	0.19	0.94
3401	0.754	24.72	1.10	0.94
3402	0.838	10.56	0.49	0.94
3403	0.886	6.00	0.31	0.94
3441	0.822	10.08	0.61	0.94
3442	0.834	4.80	0.35	0.94
3443	0.875	2.88	0.28	0.94
3491	0.832	8.40	0.53	0.94
3492	0.852	3.31	0.27	0.94
3493	0.882	1.63	0.19	0.94
3601	0.826	24.96	1.10	0.94
3602	0.894	10.32	0.49	0.94
3603	0.943	5.76	0.31	0.94
3641	0.870	9.84	0.61	0.94
3642	0.870	4.32	0.35	0.94
3643	0.910	2.40	0.28	0.94
3691	0.865	7.92	0.53	0.94
3692	0.889	2.83	0.27	0.94
3693	0.916	1.15	0.19	0.94
6201	0.719	24.72	1.10	0.97
6202	0.812	10.56	0.49	0.97
6203	0.867	6.00	0.31	0.97
6241	0.786	9.84	0.61	0.97
6242	0.810	4.80	0.35	0.97
6243	0.857	2.88	0.28	0.97
6291	0.796	8.16	0.53	0.97
6292	0.832	3.36	0.27	0.97
6293	0.866	1.68	0.19	0.97
6401	1.013	26.40	1.10	0.97
6402	1.024	10.32	0.49	0.97

DIRECT GAIN SYSTEMS (cont)

System No. (ascending order)	F	G	U_c	α
6403	1.062	5.52	0.31	0.97
6441	0.964	9.84	0.61	0.97
6442	0.966	4.08	0.35	0.97
6443	1.015	2.16	0.28	0.97
6491	0.967	7.92	0.53	0.97
6492	0.964	2.40	0.27	0.97
6493	1.020	0.96	0.19	0.97
6601	1.089	26.64	1.10	0.97
6602	1.079	10.08	0.49	0.97
6603	1.095	5.04	0.31	0.97
6641	1.013	9.60	0.61	0.97
6642	1.019	3.84	0.35	0.97
6643	1.046	1.68	0.28	0.97
6691	1.005	7.68	0.53	0.97
6692	0.997	1.92	0.27	0.97
6693	1.051	0.48	0.19	0.97
9201	0.906	25.92	1.10	0.98
9202	0.943	10.32	0.49	0.98
9203	0.983	5.52	0.31	0.98
9241	0.896	9.84	0.61	0.98
9242	0.909	4.32	0.35	0.98
9243	0.962	2.40	0.28	0.98
9291	0.889	7.92	0.53	0.98
9292	0.926	2.88	0.27	0.98
9293	0.967	1.20	0.19	0.98
9401	1.191	27.60	1.10	0.98
9402	1.131	10.08	0.49	0.98
9403	1.149	5.04	0.31	0.98
9441	1.050	9.60	0.61	0.98
9442	1.063	3.84	0.35	0.98
9443	1.095	1.68	0.28	0.98
9491	1.041	7.68	0.53	0.98
9492	1.059	2.16	0.27	0.98
9493	1.097	0.48	0.19	0.98
9601	1.268	27.84	1.10	0.98
9602	1.200	10.08	0.49	0.98
9603	1.220	5.04	0.31	0.98
9641	1.113	9.60	0.61	0.98
9642	1.093	3.36	0.35	0.98
9643	1.143	1.44	0.28	0.98
9691	1.088	7.44	0.53	0.98
9692	1.088	1.68	0.27	0.98
9693	1.145	0.24	0.19	0.98

VENTED TROMBE WALLS

System-Numbering Convention

First digit: Mass thickness in 6-in. increments (1, 2, or 3 implies 6 in., 12 in., or 18 in., respectively)

Second digit: ρck product in increments of 15 (1 or 2 implies 15 or 30, respectively)

Third digit: R-value of night insulation (0 or 9)

Fourth digit: Number of glazings (1 or 2)

Note: Not all combinations are allowed. Double-glazed systems with no night insulation and ρck equal to 15 or 30 are available in thickness of 6 in., 12 in., or 18 in. For the 12 in. wall with $\rho ck = 30$, one can also select a single-glazed system with or without R9 night insulation or a double-glazed system with R9 night insulation.

System No. (ascending order)	F	G	U_c	α
1102	0.605	5.28	0.24	0.95
1202	0.629	6.00	0.27	0.95
2102	0.638	4.32	0.19	0.95
2201	0.545	7.92	0.29	0.95
2202	0.741	5.28	0.24	0.95
2291	0.728	4.08	0.20	0.95
2292	0.861	2.16	0.15	0.95
3102	0.569	3.60	0.16	0.95
3202	0.709	4.56	0.21	0.95

UNVENTED TROMBE WALLS

System-Numbering Convention

First digit: Mass thickness in 6-in. increments (1, 2, or 3 implies 6 in., 12 in., or 18 in., respectively)

Second digit: ρck product in increments 15 (1 or 2 implies 15 or 30, respectively)

Third digit: R-value of night insulation (0 or 9)

Fourth digit: Number of glazings (1 or 2)

Note: Not all combinations are allowed. Double-glazed systems with no night insulation and ρck equal to 15 or 30 are available in thickness of 6 in., 12 in., or 18 in. For the 12 in. wall with $\rho ck = 30$ one can also select a single-glazed system with or without R9 night insulation or a double-glazed system with R9 night insulation.

System No. (ascending order)	F	G	U_c	α
1102	0.551	5.04	0.24	0.95
1202	0.616	6.00	0.27	0.95
2102	0.496	3.60	0.19	0.95
2201	0.484	7.44	0.29	0.95
2202	0.644	4.80	0.24	0.95
2291	0.611	3.12	0.20	0.95
2292	0.755	1.68	0.15	0.95
3102	0.406	2.88	0.16	0.95
3202	0.570	3.84	0.21	0.95

WATER WALLS

System-Numbering Convention

First digit: Wall thickness (1, 2, or 3 implies 6 in., 9 in., or 12 in., respectively)

Second digit: R-value of night insulation (0 or 9)

Third digit: Number of glazings (1 or 2)

Note: All combinations are not allowed. For 6 in. or 12 in. walls only double glazing without night insulation is allowed. Single or double glazing with or without night insulation are allowed with 9 in. walls.

System No. (ascending order)	F	G	U_c	α
102	0.833	6.48	0.31	0.95
210	0.735	10.80	0.41	0.95
202	0.885	6.24	0.31	0.95
291	0.873	3.84	0.25	0.95
292	0.981	1.92	0.18	0.95
302	0.907	6.00	0.21	0.95

CONCRETE BLOCK WALLS

System-Numbering Convention

First digit: Unfilled or filled (1 implies unfilled blocks and 2 implies filled)

Second digit: Number of glazings (1 or 2)

Note: Concrete blocks are 8-in. thick and no night insulation is used.

System No. (ascending order)	F	G	U_c	α
11	0.454	5.28	0.42	0.95
12	0.500	3.12	0.28	0.95
21	0.575	6.00	0.47	0.95
22	0.630	3.60	0.31	0.95

APPENDIX B

WEATHER PARAMETERS

BIRMINGHAM, ALABAMA LATITUDE = 33.3

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	183.47	114.59	78.84	57.70	43.63	33.98	27.48
VT2/DD	156.18	97.55	67.12	49.12	37.14	28.92	23.40
VT3/DD	135.57	84.68	58.26	42.64	32.24	25.11	20.31
ANNUAL DD	314	581	977	1504	2174	3019	4077
PARAMETER A	.658	.680	.641	.589	.567	.567	.590
OFF SOUTH							
VTN/DD B1	-.509	-.509	-.509	-.509	-.509	-.509	-.509
VTN/DD B2	-.095	-.095	-.095	-.095	-.095	-.095	-.095
A PARAM C1	.589	.605	.671	.750	.787	.795	.778
A PARAM C2	.004	.011	.022	.035	.046	.054	.063

MOBILE, ALABAMA LATITUDE = 30.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	1855.5	536.16	238.87	133.95	83.68	57.20	42.32
VT2/DD	1576.5	455.55	202.96	113.81	71.10	48.60	35.96
VT3/DD	1368.2	395.35	176.13	98.77	61.71	42.18	31.21
ANNUAL DD	31	132	326	642	1130	1795	2658
PARAMETER A	.701	.664	.567	.483	.465	.476	.492
OFF SOUTH							
VTN/DD B1	-.089	-.089	-.089	-.089	-.089	-.089	-.089
VTN/DD B2	-.090	-.090	-.090	-.090	-.090	-.090	-.090
A PARAM C1	-.001	-.086	-.127	-.174	-.202	-.194	-.160
A PARAM C2	.045	.038	.042	.051	.058	.067	.077

MONTGOMERY, ALABAMA LATITUDE = 32.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	370.49	199.27	115.58	74.45	52.85	40.07	31.99
VT2/DD	316.05	169.99	98.32	63.33	44.96	34.09	27.22
VT3/DD	274.47	147.63	85.35	54.98	39.02	29.59	23.63
ANNUAL DD	185	379	695	1155	1774	2572	3546
PARAMETER A	.427	.374	.419	.468	.510	.537	.550
OFF SOUTH							
VTN/DD B1	.663	.663	-.275	-.275	-.275	-.275	-.275
VTN/DD B2	-.103	-.103	-.092	-.092	-.092	-.092	-.092
A PARAM C1	-1.830	-2.206	2.013	1.724	1.499	1.347	1.231
A PARAM C2	.050	.064	.014	.022	.028	.037	.051

PHOENIX, ARIZONA LATITUDE = 33.0

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	1415.9	558.44	291.36	175.12	118.02	85.26	64.50
VT2/DD	1210.9	477.60	249.18	149.77	100.94	72.92	55.16
VT3/DD	1052.2	415.01	216.52	130.14	87.71	63.36	47.93
ANNUAL DD	43	140	328	634	1090	1713	2503
PARAMETER A	.508	.593	.593	.571	.554	.529	.511
OFF SOUTH							
VTN/DD B1	.287	.287	.287	.287	.287	.287	.287
VTN/DD B2	-.115	-.115	-.115	-.115	-.115	-.115	-.115
A PARAM C1	-.506	-.518	-.490	-.447	-.408	-.391	-.375
A PARAM C2	.012	.023	.039	.054	.070	.088	.107

PRESCOTT, ARIZONA LATITUDE = 34.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	173.09	116.89	85.65	66.45	53.63	44.77	38.32
VT2/DD	148.25	100.11	73.35	56.91	45.93	38.35	32.82
VT3/DD	128.86	87.02	63.76	49.47	39.92	33.33	28.53
ANNUAL DD	784	1304	1975	2801	3783	4937	6261
PARAMETER A	.583	.535	.497	.462	.434	.413	.398
OFF SOUTH							
VTN/DD B1	-.097	-.097	-.097	-.097	-.097	-.097	-.097
VTN/DD B2	-.120	-.120	-.120	-.120	-.120	-.120	-.120
A PARAM C1	-.012	.065	.160	.267	.377	.483	.597
A PARAM C2	.067	.094	.127	.164	.203	.238	.275

TUCSON, ARIZONA LATITUDE = 32.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 1)
VT1/DD	1309.1	592.51	318.15	193.12	127.49	92.09	69.21
VT2/DD	1120.0	506.92	272.19	163.47	107.92	77.95	59.10
VT3/DD	973.38	440.55	236.55	141.71	93.55	67.57	51.35
ANNUAL DD	69	185	416	794	1330	2025	2879
PARAMETER A	.645	.510	.422	.403	.401	.373	.363
OFF SOUTH							
VTN/DD B1	-.061	-.061	-.061	.158	.158	.158	.017
VTN/DD B2	-.118	-.118	-.118	-.083	-.083	-.083	-.111
A PARAM C1	.252	.372	.505	-.387	-.334	-.292	.395
A PARAM C2	.047	.068	.096	-.054	-.033	-.005	.170

WINSLOW, ARIZONA LATITUDE = 35.0

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	160.31	107.81	79.43	62.17	50.90	43.01	37.23
VT2/DD	137.37	92.39	68.07	53.28	43.62	36.86	31.90
VT3/DD	119.41	80.31	59.17	46.31	37.91	32.04	27.73
ANNUAL DD	913	1476	2180	3029	4014	5147	6429
PARAMETER A	.482	.482	.465	.447	.428	.412	.396
OFF SOUTH							
VTN/DD B1	-.157	-.157	-.157	-.157	-.157	-.157	-.157
VTN/DD B2	-.122	-.122	-.122	-.122	-.122	-.122	-.122
A PARAM C1	.944	.985	1.059	1.137	1.221	1.294	1.383
A PARAM C2	.082	.098	.121	.147	.177	.209	.245

YUMA, ARIZONA LATITUDE = 32.4

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	2402.3	804.25	365.88	192.42	119.03	82.89
VT2/DD	NA	2054.9	687.96	312.98	164.26	101.61	70.75
VT3/DD	NA	1785.7	597.84	271.98	142.70	88.28	61.47
ANNUAL DD	NA	36	119	308	654	1171	1870
PARAMETER A	NA	.196	.362	.446	.566	.616	.610
OFF SOUTH							
VTN/DD B1	NA	-.091	-.091	-.091	-.108	-.108	-.108
VTN/DD B2	NA	-.117	-.117	-.117	-.110	-.110	-.110
A PARAM C1	NA	.028	.059	.109	.212	.264	.320
A PARAM C2	NA	.059	.042	.046	.030	.046	.064

FORT SMITH, ARKANSAS LATITUDE = 35.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	148.07	91.48	64.01	48.41	38.60	31.96	27.22
VT2/DD	126.53	78.17	54.70	41.37	32.99	27.31	23.26
VT3/DD	109.92	67.90	47.52	35.93	28.66	23.73	20.21
ANNUAL DD	512	908	1425	2074	2844	3734	4770
PARAMETER A	.598	.606	.596	.578	.563	.553	.552
OFF SOUTH							
VTN/DD B1	-.211	-.211	-.211	-.211	-.211	-.211	-.211
VTN/DD B2	-.110	-.110	-.110	-.110	-.110	-.110	-.110
A PARAM C1	.226	.205	.201	.217	.245	.274	.292
A PARAM C2	.034	.038	.044	.051	.059	.068	.079

LITTLE ROCK, ARKANSAS LATITUDE = 34.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	191.20	116.00	77.89	56.34	43.42	35.09	29.27
VT2/DD	163.08	98.94	66.43	48.06	37.04	29.93	24.97
VT3/DD	141.62	85.92	57.69	41.73	32.16	25.99	21.68
ANNUAL DD	361	683	1141	1738	2455	3316	4346
PARAMETER A	.643	.596	.551	.520	.501	.496	.507
OFF SOUTH							
VTN/DD B1	-.433	-.433	-.433	-.433	-.433	-.433	-.433
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	-.661	-.721	-.784	-.816	-.818	-.784	-.715
A PARAM C2	.018	.026	.036	.046	.054	.064	.074

ARCATA, CALIFORNIA LATITUDE = 40.6

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	758.96	275.03	122.98	65.81	42.26	30.75	24.16
VT2/DD	647.85	234.76	105.14	[illegible]6.26	36.13	26.29	20.66
VT3/DD	562.49	203.83	91.31	48.86	31.38	22.83	17.94
ANNUAL DD	71	279	792	1794	3318	5091	6908
PARAMETER A	.673	.674	.632	.667	.658	.589	.529
OFF SOUTH							
VTN/DD B1	.210	.210	.566	.566	.566	.566	.566
VTN/DD B2	-.102	-.102	-.108	-.108	-.108	-.108	-.108
A PARAM C1	.136	-.202	-1.525	-1.682	-2.083	-2.761	-3.377
A PARAM C2	.020	.048	.093	.109	.140	.184	.222

BAKERSFIELD, CALIFORNIA LATITUDE = 35.3

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	983.14	335.12	158.77	89.93	59.23	43.57	34.26
VT2/DD	840.48	286.49	135.73	76.88	50.64	37.25	29.29
VT3/DD	730.05	248.85	117.89	66.78	43.98	32.35	25.44
ANNUAL DD	55	199	489	974	1661	2528	3576
PARAMETER A	.491	.530	.554	.642	.728	.765	.782
OFF SOUTH							
VTN/DD B1	-.175	-.175	-.175	-.175	-.175	-.175	-.175
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.112
A PARAM C1	-.843	-.762	-.645	-.470	-.345	-.276	-.228
A PARAM C2	.013	.020	.026	.029	.036	.048	.062

CHINA LAKE, CALIFORNIA LATITUDE = 35.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	530.96	250.77	146.98	97.65	70.56	54.49	44.33
VT2/DD	455.09	214.94	125.98	83.70	60.48	46.70	37.99
VT3/DD	395.56	186.82	109.50	72.75	52.57	40.59	33.02
ANNUAL DD	168	388	740	1245	1915	2751	3735
PARAMETER A	.415	.562	.622	.639	.632	.605	.573
OFF SOUTH							
VTN/DD B1	.037	.037	.037	.037	.037	.037	.037
VTN/DD B2	-.124	-.124	-.124	-.124	-.124	-.124	-.124
A PARAM C1	.152	.092	.068	.052	.042	.035	.031
A PARAM C2	.025	.024	.031	.044	.062	.083	.106

DAGGETT, CALIFORNIA LATITUDE = 34.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	834.26	362.50	201.47	126.42	87.14	64.60	50.81
VT2/DD	713.55	310.51	172.58	108.29	74.64	55.33	43.52
VT3/DD	620.06	269.86	149.99	94.11	64.87	48.09	37.82
ANNUAL DD	101	252	516	950	1585	2405	3393
PARAMETER A	.254	.402	.508	.593	.613	.604	.583
OFF SOUTH							
VTN/DD B1	.078	.418	.418	.418	.418	.418	.418
VTN/DD B2	-.117	-.122	-.122	-.122	-.122	-.122	-.122
A PARAM C1	1.243	-.890	-.762	-.713	-.734	-.767	-.805
A PARAM C2	-.014	.020	.027	.040	.061	.085	.111

EL TORO, CALIFORNIA LATITUDE = 33.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)	(M= 5)
VT1/DD	NA	2659.9	743.15	312.48	162.32	101.71	66.69
VT2/DD	NA	2272.1	634.80	266.92	138.88	87.03	53.85
VT3/DD	NA	1974.0	551.51	231.90	120.68	75.62	45.54
ANNUAL DD	NA	31	153	482	1149	2196	3558
PARAMETER A	NA	.420	.517	.491	.384	.322	.434
OFF SOUTH							
VTN/DD B1	NA	-.318	-.318	-.318	-.210	-.210	-2.367
VTN/DD B2	NA	-.112	-.112	-.112	-.117	-.117	.124
A PARAM C1	NA	.099	.003	-.292	-1.307	-2.021	2.621
A PARAM C2	NA	-.002	.029	.106	.241	.358	-.479

FRESNO, CALIFORNIA LATITUDE = 37.0

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	325.52	144.54	79.90	50.55	36.34	28.25	23.10
VT2/DD	277.87	123.38	68.21	43.15	31.02	24.11	19.72
VT3/DD	241.26	107.13	59.22	37.47	26.93	20.94	17.12
ANNUAL DD	127	343	741	1356	2171	3172	4343
PARAMETER A	.651	.715	.787	.869	.920	.954	.977
OFF SOUTH							
VTN/DD B1	-.631	-.631	-.631	-.631	-.631	-.631	-.631
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	.117	.127	.170	.219	.265	.302	.330
A PARAM C2	.008	.009	.011	.016	.022	.029	.036

LOS ANGELES, CALIFORNIA LATITUDE = 33.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M= 3)	TR70 (M= 4)
VT1/DD	NA	NA	1359.9	449.75	197.14	112.97	74.56
VT2/DD	NA	NA	1163.5	384.81	168.68	94.09	60.50
VT3/DD	NA	NA	1011.0	334.37	146.57	80.99	51.23
ANNUAL DD	NA	NA	45	240	818	1851	3300
PARAMETER A	NA	NA	.741	.631	.416	.361	.355
OFF SOUTH							
VTN/DD B1	NA	NA	-.372	-.372	-.372	-1.178	-1.022
VTN/DD B2	NA	NA	-.117	-.117	-.117	-.036	.055
A PARAM C1	NA	NA	.079	.257	.157	2.365	.177
A PARAM C2	NA	NA	.020	.067	.178	-.115	-.393

MOUNT SHASTA, CALIFORNIA LATITUDE = 41.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	99.02	59.97	42.31	32.65	26.59	22.42	19.38
VT2/DD	84.64	51.26	36.17	27.91	22.73	19.16	16.57
VT3/DD	73.52	44.53	31.41	24.24	19.74	16.63	14.39
ANNUAL DD	656	1299	2170	3216	4434	5809	7314
PARAMETER A	.768	.802	.792	.773	.768	.766	.758
OFF SOUTH							
VTN/DD B1	.382	.382	.382	.382	.382	.382	.382
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.108	-.108
A PARAM C1	-.773	-.858	-.971	-1.052	-1.079	-1.086	-1.100
A PARAM C2	.006	.015	.027	.038	.049	.061	.074

OAKLAND, CALIFORNIA LATITUDE = 37.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	642.88	214.95	104.72	63.77	44.97	34.70
VT2/DD	NA	549.00	183.56	89.43	54.46	38.40	29.63
VT3/DD	NA	476.80	159.42	77.67	47.30	33.35	25.73
ANNUAL DD	NA	60	245	741	1734	3215	4918
PARAMETER A	NA	.600	.814	.898	.872	.817	.710
OFF SOUTH							
VTN/DD B1	NA	-.953	-.953	-.953	-.953	-.953	-.953
VTN/DD B2	NA	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	NA	.606	.677	.826	.913	.922	.998
A PARAM C2	NA	-.009	-.004	.017	.051	.093	.142

POINT MUGU, CALIFORNIA LATITUDE = 34.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M= 3)	TR60 (M= 3)	TR65 (M= 3)	TR70 (M= 5)
VT1/DD	NA	2548.7	724.70	311.40	151.81	91.52	56.65
VT2/DD	NA	2181.9	620.39	258.97	126.25	76.11	45.70
VT3/DD	NA	1896.1	539.13	222.73	108.58	65.46	38.61
ANNUAL DD	NA	38	177	524	1237	2430	4006
PARAMETER A	NA	.460	.545	.515	.528	.433	.527
OFF SOUTH							
VTN/DD B1	NA	-.071	-.071	-.125	-.125	-.125	-1.520
VTN/DD B2	NA	-.119	-.119	-.028	-.028	-.028	.132
A PARAM C1	NA	-.376	-.287	-.343	-.597	-1.203	1.165
A PARAM C2	NA	.096	.105	-.156	-.101	-.061	-.391

RED BLUFF, CALIFORNIA — LATITUDE = 40.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M=12)
VT1/DD	264.10	132.62	77.98	52.73	39.10	30.73	24.80
VT2/DD	225.88	113.43	66.69	45.10	33.44	26.28	21.23
VT3/DD	196.20	98.53	57.93	39.18	29.05	22.83	18.44
ANNUAL DD	137	378	817	1455	2277	3277	4453
PARAMETER A	.714	.767	.762	.740	.737	.749	.790
OFF SOUTH							
VTN/DD B1	-.410	-.410	-.410	-.410	-.410	-.410	-.538
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.116
A PARAM C1	-.046	-.044	-.001	.039	.078	.113	.428
A PARAM C2	-.001	.003	.012	.023	.034	.043	.058

SAN DIEGO, CALIFORNIA — LATITUDE = 32.4

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	NA	1939.1	546.14	215.22	112.32	73.74
VT2/DD	NA	NA	1654.1	465.88	183.59	95.81	62.90
VT3/DD	NA	NA	1436.7	404.66	159.47	83.22	54.64
ANNUAL DD	NA	NA	31	159	572	1460	2826
PARAMETER A	NA	NA	.376	.600	.535	.456	.383
OFF SOUTH							
VTN/DD B1	NA	NA	-.198	-.198	-.198	-.198	-.198
VTN/DD B2	NA	NA	-.107	-.107	-.107	-.107	-.107
A PARAM C1	NA	NA	-.027	-.405	-1.062	-1.689	-2.437
A PARAM C2	NA	NA	-.013	.020	.082	.168	.267

SAN FRANCISCO, CALIFORNIA TM — LATITUDE = 37.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	565.00	212.21	107.57	66.69	47.03	36.18
VT2/DD	NA	482.59	181.26	91.88	56.96	40.17	30.90
VT3/DD	NA	419.14	157.42	79.80	49.47	34.89	26.84
ANNUAL DD	NA	90	331	982	2175	3703	5395
PARAMETER A	NA	.681	.828	.863	.814	.708	.608
OFF SOUTH							
VTN/DD B1	NA	-.770	-.770	-.770	-.770	-.770	-.770
VTN/DD B2	NA	-.108	-.108	-.108	-.108	-.108	-.108
A PARAM C1	NA	.286	.370	.495	.594	.699	.808
A PARAM C2	NA	-.005	.012	.048	.089	.140	.193

SANTA MARIA, CALIFORNIA — LATITUDE = 34.8

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 6)
VT1/DD	818.91	399.74	226.36	134.11	86.37	61.39	46.26
VT2/DD	699.61	341.50	193.39	114.58	73.78	52.44	37.29
VT3/DD	607.71	296.64	167.98	99.52	64.09	45.55	31.57
ANNUAL DD	72	192	467	1113	2253	3700	5350
PARAMETER A	.515	.720	.750	.720	.578	.417	.400
OFF SOUTH							
VTN/DD B1	-.166	-.166	-.166	-.166	-.166	-.166	-1.779
VTN/DD B2	-.111	-.111	-.111	-.111	-.111	-.111	.170
A PARAM C1	-.235	-.117	-.152	-.342	-.840	-1.596	1.077
A PARAM C2	.002	.017	.044	.104	.199	.329	-.579

SUNNYVALE, CALIFORNIA — LATITUDE = 37.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	NA	613.36	269.61	130.65	75.01	51.18	38.68
VT2/DD	NA	524.83	230.70	111.79	64.18	43.79	33.09
VT3/DD	NA	455.93	200.41	97.11	55.76	38.04	28.75
ANNUAL DD	NA	97	323	831	1730	3034	4612
PARAMETER A	NA	.871	.717	.646	.696	.716	.664
OFF SOUTH							
VTN/DD B1	NA	-.445	-.445	-.445	-.445	-.445	-.445
VTN/DD B2	NA	-.115	-.115	-.115	-.115	-.115	-.115
A PARAM C1	NA	.385	.631	.705	.555	.410	.308
A PARAM C2	NA	.015	.041	.067	.081	.108	.153

COLORADO SPRINGS, COLORADO LATITUDE = 38.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 2)	(M= 2)	(M= 2)	(M= 3)	(M= 3)
VT1/DD	122.79	90.69	70.63	56.65	46.96	40.29	34.38
VT2/DD	105.17	77.68	60.04	48.16	39.91	33.64	28.70
VT3/DD	91.41	67.51	52.08	41.77	34.62	28.96	24.71
ANNUAL DD	1414	2097	2932	3934	5097	6440	7936
PARAMETER A	.336	.310	.308	.314	.314	.328	.342
OFF SOUTH							
VTN/DD B1	-.322	-.322	-.153	-.153	-.153	-.233	-.233
VTN/DD B2	-.117	-.117	-.092	-.092	-.092	-.025	-.025
A PARAM C1	1.215	1.462	.464	.624	.798	1.205	1.356
A PARAM C2	.142	.172	.031	.057	.086	-.219	-.179

DENVER, COLORADO LATITUDE = 39.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 2)	(M= 2)	(M= 2)	(M= 2)	(M= 2)
VT1/DD	103.58	78.15	61.70	49.69	41.32	35.26	30.74
VT2/DD	88.76	66.97	52.45	42.24	35.12	29.97	26.14
VT3/DD	77.15	58.21	45.49	36.64	30.46	26.00	22.67
ANNUAL DD	1510	2209	3059	4059	5223	6542	8004
PARAMETER A	.428	.416	.418	.430	.427	.438	.429
OFF SOUTH							
VTN/DD B1	-.432	-.432	-.197	-.197	-.197	-.197	-.197
VTN/DD B2	-.119	-.119	-.091	-.091	-.091	-.091	-.091
A PARAM C1	1.202	1.436	.478	.620	.762	.904	1.064
A PARAM C2	.075	.091	-.021	-.002	.020	.044	.071

EAGLE, COLORADO LATITUDE = 39.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	53.50	43.15	35.95	30.81	26.96	23.96	21.57
VT2/DD	45.91	36.93	30.77	26.37	23.07	20.51	18.46
VT3/DD	39.91	32.08	26.73	22.91	20.05	17.82	16.04
ANNUAL DD	2666	3622	4729	5976	7352	8839	10421
PARAMETER A	.568	.585	.597	.601	.595	.577	.550
OFF SOUTH							
VTN/DD B1	.236	.466	.466	.466	.466	.466	.466
VTN/DD B2	-.125	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	.131	-.535	-.498	-.466	-.438	-.414	-.393
A PARAM C2	.075	.046	.060	.076	.094	.117	.144

GRAND JUNCTION, COLORADO LATITUDE = 39.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	69.29	52.95	42.80	35.91	30.93	27.16	24.22
VT2/DD	59.30	45.31	36.62	30.73	26.47	23.24	20.72
VT3/DD	51.52	39.37	31.82	26.70	23.00	20.20	18.01
ANNUAL DD	1397	2076	2890	3820	4870	6040	7347
PARAMETER A	.702	.693	.677	.657	.638	.624	.614
OFF SOUTH							
VTN/DD B1	.019	.019	.019	.019	.019	.019	.019
VTN/DD B2	-.113	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	.296	.270	.255	.245	.238	.235	.236
A PARAM C2	.013	.022	.033	.045	.057	.071	.084

PUEBLO, COLORADO LATITUDE = 38.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	88.66	68.92	55.74	46.44	39.65	34.46	30.46
VT2/DD	75.91	59.01	47.72	39.77	33.95	29.51	26.08
VT3/DD	65.97	51.28	41.47	34.56	29.50	25.64	22.66
ANNUAL DD	1449	2035	2755	3614	4613	5774	7107
PARAMETER A	.584	.578	.565	.555	.540	.528	.511
OFF SOUTH							
VTN/DD B1	-.311	-.311	-.311	-.311	-.311	-.311	-.311
VTN/DD B2	-.116	-.116	-.116	-.116	-.116	-.116	-.116
A PARAM C1	.974	1.036	1.117	1.197	1.293	1.386	1.500
A PARAM C2	.062	.068	.077	.089	.104	.122	.144

HARTFORD, CONNECTICUT LATITUDE = 41.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	34.62	25.30	19.66	15.98	13.43	11.57	10.16
VT2/DD	29.59	21.62	16.80	13.66	11.48	9.89	8.68
VT3/DD	25.70	18.77	14.59	11.86	9.97	8.59	7.54
ANNUAL DD	1549	2262	3115	4106	5232	6506	7927
PARAMETER A	.635	.692	.752	.806	.850	.887	.919
OFF SOUTH							
VTN/DD B1	.024	.024	.024	.024	.024	.024	.024
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	-.494	-.402	-.326	-.267	-.224	-.190	-.164
A PARAM C2	.032	.034	.035	.037	.039	.042	.045

WILMINGTON, DELAWARE LATITUDE = 39.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	62.23	44.34	33.95	27.40	22.93	19.72	17.29
VT2/DD	53.17	37.89	29.01	23.41	19.60	16.85	14.78
VT3/DD	46.18	32.91	25.19	20.34	17.02	14.64	12.84
ANNUAL DD	902	1493	2239	3105	4094	5211	6493
PARAMETER A	.626	.630	.615	.600	.593	.591	.597
OFF SOUTH							
VTN/DD B1	-.421	-.421	-.421	-.421	-.421	-.421	-.421
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.108	-.108
A PARAM C1	.861	.945	1.034	1.099	1.131	1.143	1.125
A PARAM C2	.025	.033	.044	.054	.065	.075	.085

WASHINGTON DC LATITUDE = 38.9

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M=12)
VT1/DD	68.81	49.61	37.81	30.39	25.30	21.61	18.79
VT2/DD	58.80	42.39	32.31	25.96	21.62	18.47	16.08
VT3/DD	51.07	36.82	28.06	22.55	18.77	16.04	13.97
ANNUAL DD	894	1430	2113	2930	3887	5004	6284
PARAMETER A	.594	.557	.538	.536	.541	.554	.569
OFF SOUTH							
VTN/DD B1	.621	.621	.621	.621	.621	.621	-.192
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.108	-.112
A PARAM C1	-1.224	-1.462	-1.602	-1.658	-1.666	-1.641	.923
A PARAM C2	.036	.045	.054	.063	.072	.080	.104

APALACHICOLA, FLORIDA LATITUDE = 30.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	1417.8	578.73	286.23	161.08	100.04	66.88	48.11
VT2/DD	1205.3	491.99	243.33	136.94	85.05	56.85	40.90
VT3/DD	1046.1	427.02	211.20	118.85	73.81	49.35	35.49
ANNUAL DD	37	112	265	524	932	1534	2342
PARAMETER A	.719	.675	.578	.521	.516	.532	.547
OFF SOUTH							
VTN/DD B1	-.365	-.365	-.365	-.365	-.365	-.365	-.365
VTN/DD B2	-.092	-.092	-.092	-.092	-.092	-.092	-.092
A PARAM C1	.242	.294	.394	.467	.478	.467	.456
A PARAM C2	.011	.010	.014	.019	.027	.035	.048

DAYTONA BEACH, FLORIDA LATITUDE = 29.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	1488.1	620.18	323.32	194.58	124.15	83.75	59.75
VT2/DD	1265.5	527.40	274.95	165.47	105.58	71.22	50.81
VT3/DD	1098.6	457.87	238.70	143.66	91.66	61.83	44.11
ANNUAL DD	26	65	151	298	570	1009	1652
PARAMETER A	.302	.461	.623	.726	.772	.744	.689
OFF SOUTH							
VTN/DD B1	-.402	-.402	-.402	-.402	-.402	-.402	-.402
VTN/DD B2	-.096	-.096	-.096	-.096	-.096	-.096	-.096
A PARAM C1	.352	.211	.220	.264	.372	.532	.722
A PARAM C2	.046	.026	.022	.024	.029	.040	.056

JACKSONVILLE, FLORIDA LATITUDE = 30.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	640.73	324.39	196.57	126.68	84.85	60.29	45.41
VT2/DD	545.04	275.94	167.21	107.76	72.18	51.28	38.63
VT3/DD	473.16	239.55	145.16	93.55	62.66	44.52	33.54
ANNUAL DD	85	187	354	615	1004	1561	2321
PARAMETER A	.696	.633	.580	.571	.565	.558	.555
OFF SOUTH							
VTN/DD B1	-.511	-.511	-.511	-.511	-.511	-.511	-.511
VTN/DD B2	-.095	-.095	-.095	-.095	-.095	-.095	-.095
A PARAM C1	.297	.329	.384	.422	.445	.484	.543
A PARAM C2	.001	.007	.013	.020	.028	.037	.049

MIAMI, FLORIDA LATITUDE = 25.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	NA	NA	NA	1056.0	503.81	282.40	179.75
VT2/DD	NA	NA	NA	897.18	428.03	239.92	152.72
VT3/DD	NA	NA	NA	778.88	371.59	208.29	132.58
ANNUAL DD	NA	NA	NA	59	133	264	507
PARAMETER A	NA	NA	NA	.365	.361	.454	.534
OFF SOUTH							
VTN/DD B1	NA	NA	NA	.022	.022	.022	.022
VTN/DD B2	NA	NA	NA	-.091	-.091	-.091	-.091
A PARAM C1	NA	NA	NA	1.057	1.048	.813	.770
A PARAM C2	NA	NA	NA	.041	.045	.040	.052

ORLANDO, FLORIDA LATITUDE = 28.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	1799.4	668.95	329.72	183.50	114.01	77.22
VT2/DD	NA	1529.3	568.56	280.24	155.96	96.90	65.63
VT3/DD	NA	1327.6	493.57	243.28	135.39	84.12	56.98
ANNUAL DD	NA	27	80	193	413	796	1389
PARAMETER A	NA	.327	.532	.564	.601	.586	.577
OFF SOUTH							
VTN/DD B1	NA	-.115	-.115	-.115	-.115	-.115	-.115
VTN/DD B2	NA	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	NA	-.553	-.305	-.273	-.216	-.155	-.082
A PARAM C2	NA	-.015	-.003	.006	.016	.033	.056

TALLAHASSEE, FLORIDA LATITUDE = 30.2

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	465.39	268.10	168.25	109.37	75.46	55.02	41.97
VT2/DD	395.55	228.38	143.00	92.96	64.13	46.77	35.67
VT3/DD	343.31	198.29	124.12	80.68	55.66	40.59	30.96
ANNUAL DD	143	295	523	855	1323	1958	2793
PARAMETER A	.489	.504	.491	.494	.501	.501	.508
OFF SOUTH							
VTN/DD B1	-.186	-.271	-.186	-.186	-.186	-.186	-.186
VTN/DD B2	-.092	-.100	-.092	-.092	-.092	-.092	-.092
A PARAM C1	-.057	.327	.058	.092	.112	.137	.178
A PARAM C2	-.002	.045	.028	.034	.040	.048	.061

TAMPA, FLORIDA LATITUDE = 27.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	NA	1685.2	741.22	396.04	220.55	122.89	78.09
VT2/DD	NA	1432.6	630.15	336.69	185.26	103.23	65.59
VT3/DD	NA	1243.9	547.14	292.34	160.23	89.28	56.73
ANNUAL DD	NA	36	101	232	474	874	1477
PARAMETER A	NA	.380	.374	.369	.410	.522	.560
OFF SOUTH							
VTN/DD B1	NA	.074	.074	.074	.488	.488	.488
VTN/DD B2	NA	-.096	-.096	-.096	-.057	-.057	-.057
A PARAM C1	NA	.126	.094	.085	-1.463	-1.164	-1.107
A PARAM C2	NA	.031	.035	.048	-.099	-.061	-.039

WEST PALM BEACH, FLORIDA LATITUDE = 26.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	NA	NA	NA	1178.1	519.19	269.83	150.23
VT2/DD	NA	NA	NA	999.57	440.49	228.93	127.46
VT3/DD	NA	NA	NA	867.51	382.29	198.68	110.62
ANNUAL DD	NA	NA	NA	44	123	281	600
PARAMETER A	NA	NA	NA	.317	.681	.705	.644
OFF SOUTH							
VTN/DD B1	NA	NA	NA	.270	.270	.270	.270
VTN/DD B2	NA	NA	NA	-.087	-.087	-.087	-.087
A PARAM C1	NA	NA	NA	.961	.418	.369	.348
A PARAM C2	NA	NA	NA	.056	.026	.033	.050

ATLANTA, GEORGIA LATITUDE = 33.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	186.80	107.76	69.42	48.63	36.66	29.20	24.25
VT2/DD	159.01	91.73	59.09	41.39	31.21	24.86	20.64
VT3/DD	138.03	79.63	51.30	35.93	27.09	21.58	17.92
ANNUAL DD	332	639	1079	1657	2392	3310	4417
PARAMETER A	.663	.619	.587	.593	.614	.639	.661
OFF SOUTH							
VTN/DD B1	.321	.321	.321	.321	.321	.321	.321
VTN/DD B2	-.094	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	-.569	-.702	-.832	-.885	-.893	-.886	-.871
A PARAM C2	.007	.014	.024	.029	.033	.039	.048

AUGUSTA, GEORGIA LATITUDE = 33.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 2)	(M= 2)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	258.19	153.24	96.57	65.46	47.62	36.50	29.16
VT2/DD	218.34	129.59	82.16	55.69	40.51	31.06	24.81
VT3/DD	189.21	112.30	71.31	48.34	35.16	26.95	21.53
ANNUAL DD	314	576	952	1458	2115	2938	3957
PARAMETER A	.537	.494	.519	.562	.597	.620	.644
OFF SOUTH							
VTN/DD B1	-.302	-.302	-.056	-.056	-.056	-.056	-.056
VTN/DD B2	-.075	-.075	-.092	-.092	-.092	-.092	-.092
A PARAM C1	.732	.855	.069	.085	.092	.094	.092
A PARAM C2	-.037	-.039	.025	.027	.030	.036	.043

MACON, GEORGIA LATITUDE = 32.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	267.47	145.68	90.57	62.10	45.32	34.86	28.05
VT2/DD	227.65	123.99	77.09	52.85	38.57	29.67	23.87
VT3/DD	197.62	107.64	66.92	45.88	33.48	25.76	20.72
ANNUAL DD	208	430	775	1244	1859	2643	3624
PARAMETER A	.716	.744	.731	.733	.755	.768	.770
OFF SOUTH							
VTN/DD B1	.111	.111	.111	.111	.111	.111	.111
VTN/DD B2	-.095	-.095	-.095	-.095	-.095	-.095	-.095
A PARAM C1	-.354	-.374	-.413	-.435	-.434	-.435	-.439
A PARAM C2	.008	.008	.012	.018	.023	.030	.039

SAVANNAH, GEORGIA LATITUDE = 32.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	483.93	239.91	144.08	93.18	64.28	47.43	36.62
VT2/DD	412.16	204.33	122.71	79.36	54.75	40.39	31.19
VT3/DD	357.86	177.41	106.55	68.91	47.54	35.07	27.08
ANNUAL DD	155	328	599	995	1530	2227	3129
PARAMETER A	.624	.597	.556	.536	.546	.559	.581
OFF SOUTH							
VTN/DD B1	.421	.421	.421	.421	.421	.421	.421
VTN/DD B2	-.100	-.100	-.100	-.100	-.100	-.100	-.100
A PARAM C1	-.806	-.922	-1.021	-1.051	-1.010	-.964	-.896
A PARAM C2	.014	.024	.030	.036	.040	.047	.057

BOISE, IDAHO LATITUDE = 43.3

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	70.75	46.46	34.08	26.88	22.18	18.89	16.44
VT2/DD	60.58	39.83	29.22	23.04	19.02	16.19	14.09
VT3/DD	52.63	34.61	25.39	20.02	16.52	14.07	12.25
ANNUAL DD	973	1651	2494	3503	4667	5981	7429
PARAMETER A	.719	.754	.783	.809	.831	.853	.871
OFF SOUTH							
VTN/DD B1	-.438	.468	.468	.468	.468	.468	.468
VTN/DD B2	-.115	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	1.255	-.862	-.809	-.765	-.734	-.711	-.695
A PARAM C2	.014	.029	.035	.042	.048	.055	.062

LEWISTON, IDAHO LATITUDE = 46.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	45.07	31.12	22.12	16.82	13.57	11.37	9.78
VT2/DD	38.47	26.57	18.93	14.39	11.61	9.73	8.37
VT3/DD	33.40	23.07	16.45	12.50	10.09	8.45	7.27
ANNUAL DD	774	1368	2175	3169	4353	5701	7186
PARAMETER A	.745	.772	.812	.871	.929	.981	1.022
OFF SOUTH							
VTN/DD B1	.999	.999	.166	.166	.166	.166	.166
VTN/DD B2	-.100	-.100	-.111	-.111	-.111	-.111	-.111
A PARAM C1	-.913	-1.032	.561	.468	.400	.351	.315
A PARAM C2	.001	.007	.034	.036	.037	.038	.040

POCATELLO, IDAHO LATITUDE = 42.6

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	45.44	33.91	26.95	22.36	19.10	16.67	14.79
VT2/DD	38.94	29.05	23.09	19.16	16.36	14.28	12.67
VT3/DD	33.83	25.25	20.07	16.65	14.22	12.41	11.01
ANNUAL DD	1740	2587	3583	4711	5969	7352	8847
PARAMETER A	.727	.806	.849	.875	.894	.909	.918
OFF SOUTH							
VTN/DD B1	.134	.134	.134	.134	.134	.134	.134
VTN/DD B2	-.116	-.116	-.116	-.116	-.116	-.116	-.116
A PARAM C1	-.593	-.592	-.581	-.567	-.548	-.525	-.508
A PARAM C2	.024	.031	.038	.044	.051	.058	.064

CHICAGO, ILLINIOS LATITUDE = 41.8

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	39.95	29.06	22.65	18.51	15.62	13.49	11.86
VT2/DD	34.19	24.87	19.38	15.84	13.37	11.54	10.15
VT3/DD	29.70	21.60	16.84	13.76	11.61	10.03	8.82
ANNUAL DD	1581	2284	3100	4026	5076	6272	7622
PARAMETER A	.546	.618	.677	.724	.768	.809	.848
OFF SOUTH							
VTN/DD B1	-.088	-.088	-.088	-.088	-.088	-.088	-.088
VTN/DD B2	-.111	-.111	-.111	-.111	-.111	-.111	-.111
A PARAM C1	.870	.784	.721	.676	.642	.618	.602
A PARAM C2	.048	.047	.047	.049	.051	.053	.055

MOLINE, ILLINIOS LATITUDE = 41.3

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	34.65	27.60	22.79	19.34	16.79	14.84	13.29
VT2/DD	29.63	23.60	19.48	16.54	14.36	12.69	11.36
VT3/DD	25.73	20.50	16.92	14.36	12.47	11.02	9.87
ANNUAL DD	1722	2411	3208	4126	5182	6381	7735
PARAMETER A	.733	.724	.729	.741	.759	.775	.791
OFF SOUTH							
VTN/DD B1	.115	.115	.115	.115	.115	.115	.115
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.108	-.108
A PARAM C1	-.143	-.072	-.008	.057	.120	.180	.229
A PARAM C2	.017	.022	.027	.031	.036	.043	.049

SPRINGFIELD, ILLINIOS					LATITUDE = 39.5		
	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	49.80	35.75	27.40	22.03	18.40	15.79	13.84
VT2/DD	42.58	30.56	23.43	18.83	15.73	13.50	11.83
VT3/DD	36.98	26.55	20.35	16.36	13.66	11.73	10.27
ANNUAL DD	1321	1917	2635	3487	4479	5605	6876
PARAMETER A	.524	.615	.684	.738	.776	.804	.829
OFF SOUTH							
VTN/DD B1	-.300	-.300	-.300	-.300	-.300	-.300	-.300
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.108	-.108
A PARAM C1	.619	.486	.409	.369	.352	.347	.344
A PARAM C2	.029	.029	.030	.032	.036	.041	.046

EVANSVILLE, INDIANA					LATITUDE = 38.0		
	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	69.88	46.16	33.82	26.41	21.53	18.10	15.55
VT2/DD	59.67	39.42	28.88	22.56	18.39	15.46	13.28
VT3/DD	51.81	34.23	25.08	19.59	15.97	13.42	11.53
ANNUAL DD	910	1453	2111	2885	3784	4845	6073
PARAMETER A	.424	.504	.551	.582	.617	.662	.707
OFF SOUTH							
VTN/DD B1	-.220	-.220	-.220	-.220	-.220	-.220	-.220
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	1.857	1.485	1.316	1.211	1.114	1.012	.926
A PARAM C2	.047	.045	.047	.050	.051	.053	.055

FORT WAYNE, INDIANA					LATITUDE = 41.0		
	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)
VT1/DD	28.15	22.22	18.30	15.55	12.99	11.06	9.61
VT2/DD	24.03	18.96	15.62	13.27	11.08	9.43	8.20
VT3/DD	20.86	16.46	13.56	11.52	9.62	8.19	7.12
ANNUAL DD	1649	2341	3141	4061	5121	6340	7731
PARAMETER A	.678	.643	.637	.648	.719	.789	.853
OFF SOUTH							
VTN/DD B1	.193	.193	.193	.193	.688	.688	.688
VTN/DD B2	-.101	-.101	-.101	-.101	-.097	-.097	-.097
A PARAM C1	-.046	-.082	-.101	-.105	-1.220	-1.080	-.967
A PARAM C2	.036	.044	.048	.051	.038	.038	.039

INDIANAPOLIS, INDIANA					LATITUDE = 39.4		
	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	34.33	26.83	20.71	16.58	13.80	11.82	10.34
VT2/DD	29.30	22.90	17.67	14.14	11.78	10.09	8.83
VT3/DD	25.44	19.88	15.34	12.28	10.22	8.76	7.66
ANNUAL DD	1392	2032	2807	3703	4713	5867	7185
PARAMETER A	.595	.593	.664	.732	.784	.831	.878
OFF SOUTH							
VTN/DD B1	.527	.527	.731	.731	.731	.731	.731
VTN/DD B2	-.102	-.102	-.101	-.101	-.101	-.101	-.101
A PARAM C1	-.134	-.244	-.806	-.768	-.747	-.728	-.706
A PARAM C2	.035	.041	.037	.037	.038	.039	.041

SOUTH BEND, INDIANA					LATITUDE = 41.4		
	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)
VT1/DD	28.04	21.48	17.30	14.48	12.44	10.84	9.49
VT2/DD	23.93	18.33	14.76	12.35	10.62	9.25	8.10
VT3/DD	20.77	15.91	12.82	10.73	9.22	8.03	7.03
ANNUAL DD	1564	2279	3125	4098	5206	6464	7884
PARAMETER A	.657	.683	.711	.741	.774	.816	.871
OFF SOUTH							
VTN/DD B1	-.462	-.462	-.462	-.462	-.462	-.228	-.228
VTN/DD B2	-.101	-.101	-.101	-.101	-.101	-.099	-.099
A PARAM C1	.951	.900	.853	.810	.771	.277	.266
A PARAM C2	.032	.034	.037	.039	.041	.039	.040

BURLINGTON, IOWA — LATITUDE = 40.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M=12)
VT1/DD	40.89	32.95	27.41	23.43	20.45	18.14	16.06
VT2/DD	34.99	28.19	23.45	20.05	17.50	15.52	13.76
VT3/DD	30.40	24.49	20.38	17.42	15.20	13.49	11.95
ANNUAL DD	1635	2326	3129	4035	5061	6232	7563
PARAMETER A	.677	.648	.625	.616	.621	.628	.655
OFF SOUTH							
VTN/DD B1	-.434	-.434	-.434	-.434	-.434	-.434	-.198
VTN/DD B2	-.113	-.113	-.113	-.113	-.113	-.113	-.116
A PARAM C1	.393	.438	.473	.499	.518	.541	-.097
A PARAM C2	.024	.031	.039	.046	.053	.061	.076

DES MOINES, IOWA — LATITUDE = 41.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	35.18	28.85	24.39	21.12	18.62	16.65	15.06
VT2/DD	30.11	24.69	20.87	18.07	15.93	14.25	12.89
VT3/DD	26.16	21.45	18.13	15.70	13.84	12.38	11.20
ANNUAL DD	1909	2619	3444	4384	5453	6678	8067
PARAMETER A	.678	.665	.655	.654	.660	.673	.687
OFF SOUTH							
VTN/DD B1	.331	331	.331	.331	.331	.331	.331
VTN/DD B2	-.113	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	-.369	-.431	-.478	-.501	-.505	-.493	-.476
A PARAM C2	.027	.033	.039	.045	.051	.058	.066

MASON CITY, IOWA — LATITUDE = 43.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	30.12	24.20	20.22	17.36	15.21	13.53	12.19
VT2/DD	25.82	20.75	17.33	14.88	13.04	11.60	10.45
VT3/DD	22.44	18.03	15.06	12.93	11.33	10.08	9.08
ANNUAL DD	2652	3492	4428	5473	6635	7930	9372
PARAMETER A	.603	.659	.696	.732	.764	.796	.826
OFF SOUTH							
VTN/DD B1	-.894	-.894	-.894	-.894	-.894	-.894	-.894
VTN/DD B2	-.118	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	2.432	2.237	2.127	2.023	1.932	1.848	1.773
A PARAM C2	.045	.046	.048	.051	.054	.056	.060

SIOUX CITY, IOWA — LATITUDE = 42.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	36.53	30.17	25.67	22.33	19.69	17.25	15.34
VT2/DD	31.29	25.85	21.98	19.13	16.87	14.78	13.14
VT3/DD	27.19	22.46	19.10	16.62	14.66	12.84	11.42
ANNUAL DD	2217	2947	3786	4736	5800	6992	8333
PARAMETER A	.508	.514	.519	.526	.540	.586	.629
OFF SOUTH							
VTN/DD B1	.476	.476	.476	.476	.040	.040	.040
VTN/DD B2	-.116	-.116	-.116	-.116	-.117	-.117	-.117
A PARAM C1	-.916	-.969	-1.036	-1.091	.379	.289	.214
A PARAM C2	.042	.051	.058	.065	.072	.074	.077

DODGE CITY, KANSAS — LATITUDE = 37.8

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	81.97	61.62	48.81	40.07	33.88	29.34	25.87
VT2/DD	70.12	52.71	41.75	34.28	28.98	25.09	22.13
VT3/DD	60.92	45.80	36.27	29.78	25.18	21.80	19.23
ANNUAL DD	1254	1860	2580	3419	4392	5506	6775
PARAMETER A	.611	.572	.541	.522	.514	.516	.521
OFF SOUTH							
VTN/DD B1	-.881	-.881	-.881	-.881	-.881	-.881	-.881
VTN/DD B2	-.113	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	1.663	1.935	2.166	2.338	2.426	2.440	2.421
A PARAM C2	.036	.044	.055	.066	.077	.088	.101

GOODLAND, KANSAS — LATITUDE = 39.2

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	89.92	65.90	51.24	41.81	35.31	30.56	26.93
VT2/DD	77.04	56.56	43.98	35.88	30.30	26.22	23.11
VT3/DD	66.96	49.17	38.23	31.20	26.34	22.80	20.10
ANNUAL DD	1546	2267	3123	4115	5235	6499	7915
PARAMETER A	.413	.422	.439	.443	.440	.435	.430
OFF SOUTH							
VTN/DD B1	-.575	-.266	-.266	-.266	-.266	-.266	-.266
VTN/DD B2	-.119	-.125	-.125	-.125	-.125	-.125	-.125
A PARAM C1	1.642	.315	.402	.479	.539	.577	.586
A PARAM C2	.080	.124	.133	.148	.168	.189	.212

TOPEKA, KANSAS — LATITUDE = 39.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	62.38	48.12	37.97	30.60	25.51	21.86	19.13
VT2/DD	53.36	41.16	32.51	26.20	21.84	18.72	16.38
VT3/DD	46.36	35.76	28.24	22.77	18.98	16.26	14.23
ANNUAL DD	1386	1967	2665	3477	4405	5458	6673
PARAMETER A	.514	.485	.501	.547	.589	.625	.655
OFF SOUTH							
VTN/DD B1	.205	.205	-.234	-.234	-.234	-.234	-.234
VTN/DD B2	-.112	-.112	-.114	-.114	-.114	-.114	-.114
A PARAM C1	-1.096	-1.227	.431	.377	.344	.331	.331
A PARAM C2	.040	.050	.064	.064	.065	.068	.074

LEXINGTON, KENTUCKY — LATITUDE = 38.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M=12)
VT1/DD	55.14	40.86	31.61	25.47	21.18	18.06	15.28
VT2/DD	47.04	34.85	26.96	21.72	18.07	15.41	13.04
VT3/DD	40.84	30.26	23.41	18.86	15.68	13.38	11.32
ANNUAL DD	954	1454	2089	2862	3781	4862	6109
PARAMETER A	.565	.586	.595	.600	.610	.628	.687
OFF SOUTH							
VTN/DD B1	-.335	-.335	-.335	-.335	-.335	-.335	-.102
VTN/DD B2	-.100	-.100	-.100	-.100	-.100	-.100	-.101
A PARAM C1	.588	.577	.568	.563	.551	.534	-.085
A PARAM C2	.029	.033	.038	.043	.049	.054	.058

LOUISVILLE, KENTUCKY — LATITUDE = 38.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	61.55	44.84	34.34	27.44	22.69	19.22	16.66
VT2/DD	52.52	38.26	29.30	23.41	19.36	16.40	14.21
VT3/DD	45.60	33.22	25.44	20.32	16.81	14.24	12.34
ANNUAL DD	871	1394	2044	2814	3716	4756	5966
PARAMETER A	.664	.636	.624	.621	.628	.639	.654
OFF SOUTH							
VTN/DD B1	-.225	-.225	-.225	-.225	-.225	-.225	-.225
VTN/DD B2	-.101	-.101	-.101	-.101	-.101	-.101	-.101
A PARAM C1	.425	.448	.440	.429	.418	.409	.401
A PARAM C2	.024	.031	.037	.042	.047	.052	.058

BATON ROUGE, LOUISIANA — LATITUDE = 30.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	634.57	381.07	203.60	115.23	74.88	53.01	39.82
VT2/DD	541.10	324.94	173.05	97.94	63.64	45.05	33.84
VT3/DD	469.93	282.20	150.20	85.01	55.23	39.11	29.37
ANNUAL DD	72	167	359	690	1169	1813	2643
PARAMETER A	.496	.474	.480	.491	.498	.505	.517
OFF SOUTH							
VTN/DD B1	-.924	-.924	-.049	-.049	-.049	-.049	-.049
VTN/DD B2	-.104	-.104	-.091	-.091	-.091	-.091	-.091
A PARAM C1	1.234	1.922	-1.006	-.820	-.713	-.606	-.485
A PARAM C2	.022	.047	.012	.022	.029	.039	.052

LAKE CHARLES, LOUISIANA — LATITUDE = 30.1

DUE SOUTH	TR40 (M=12)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	852.00	357.05	170..18	97.94	64.62	46.78	35.41
VT2/DD	725.66	303.29	144.56	83.19	54.89	39.74	30.08
VT3/DD	630.05	263.20	125.45	72.20	47.63	34.48	26.10
ANNUAL DD	64	155	329	629	1088	1700	2497
PARAMETER A	.407	.535	.607	.661	652	.646	.650
OFF SOUTH							
VTN/DD B1	-1.134	-.063	-.063	-.063	-.063	-.063	-.063
VTN/DD B2	-.098	-.088	-.088	-.088	-.088	-.088	-.088
A PARAM C1	3.123	-.827	-.646	-.525	-.458	-.377	-.291
A PARAM C2	.051	.007	.009	.013	.022	.031	.041

NEW ORLEANS, LOUISIANA — LATITUDE = 29.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	958.43	436.79	228.05	136.85	91.07	63.59	46.56
VT2/DD	814.85	371.36	193.89	116.35	77.43	54.06	39.58
VT3/DD	707.33	322.35	168.30	101.00	67.21	46.93	34.36
ANNUAL DD	45	124	280	544	940	1526	2323
PARAMETER A	.518	.606	.628	.594	.565	.559	.563
OFF SOUTH							
VTN/DD B1	-.662	-.662	-.662	-.662	-.662	-.662	-.662
VTN/DD B2	-.093	-.093	-.093	-.093	-.093	-.093	-.093
A PARAM C1	-.045	.046	.165	.304	.447	.596	.725
A PARAM C2	-.009	-.002	.007	.018	.029	.042	.057

SHREVEPORT, LOUISIANA — LATITUDE = 32.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	552.54	259.42	142.71	86.56	59.98	44.91	35.30
VT2/DD	471.46	221.35	121.77	73.66	51.05	38.22	30.04
VT3/DD	409.46	192.24	105.76	63.95	44.31	33.18	26.08
ANNUAL DD	111	293	627	1104	1709	2466	3393
PARAMETER A	.580	.504	.448	.471	.478	.495	.516
OFF SOUTH							
VTN/DD B1	-.082	-.082	-.082	-.492	-.492	-.492	-.492
VTN/DD B2	-.104	-.104	-.104	-.094	-.094	-.094	-.094
A PARAM C1	-.546	-.702	-.829	.736	.729	.703	.669
A PARAM C2	.024	.045	.068	.036	.042	.050	.060

BANGOR, MAINE — LATITUDE = 44.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	33.35	26.61	22.12	18.83	16.20	14.21	12.66
VT2/DD	28.58	22.80	18.95	16.14	13.89	12.18	10.85
VT3/DD	24.83	19.81	16.47	14.03	12.07	10.59	9.43
ANNUAL DD	2370	3232	4229	5381	6692	8167	9780
PARAMETER A	.394	.436	.472	.512	.564	.608	.641
OFF SOUTH							
VTN/DD B1	-.023	-.023	-.023	.270	.270	.270	.270
VTN/DD B2	-.117	-.117	-.117	-.119	-.119	-.119	-.119
A PARAM C1	1.203	1.066	.946	-.242	-.252	-.272	-.301
A PARAM C2	.090	.090	.092	.100	.099	.100	.104

CARIBOU, MAINE — LATITUDE = 46.9

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	19.22	15.85	13.48	11.72	10.37	9.30	8.42
VT2/DD	16.47	13.58	11.55	10.04	8.88	7.96	7.22
VT3/DD	14.31	11.80	10.03	8.73	7.72	6.92	6.27
ANNUAL DD	3285	4256	5369	6614	8011	9562	11228
PARAMETER A	.674	.740	.793	.838	.879	.915	.939
OFF SOUTH							
VTN/DD B1	.169	.169	.169	.169	.169	.169	.169
VTN/DD B2	-.114	-.114	-.114	-.114	-.114	-.114	-.114
A PARAM C1	.563	.558	.546	.529	.509	.489	.476
A PARAM C2	.039	.040	.041	.043	.045	.048	.052

PORTLAND, MAINE LATITUDE = 43.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	33.77	26.30	21.38	17.76	15.16	13.23	11.73
VT2/DD	28.89	22.50	18.29	15.22	13.00	11.34	10.05
VT3/DD	25.10	19.55	15.89	13.23	11.29	9.85	8.74
ANNUAL DD	1831	2627	3583	4696	5975	7421	8997
PARAMETER A	.500	.544	.575	.620	.662	.700	.725
OFF SOUTH							
VTN/DD B1	-.822	-.822	-.822	.166	.166	.166	.166
VTN/DD B2	-.111	-.111	-.111	-.118	-.118	-.118	-.118
A PARAM C1	1.624	1.561	1.539	-1.384	-1.208	-1.061	-.951
A PARAM C2	.037	.044	.051	.079	.082	.085	.091

BALTIMORE, MARYLAND LATITUDE = 39.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	68.86	48.65	36.94	29.65	24.06	20.05	17.18
VT2/DD	58.85	41.58	31.57	25.33	20.58	17.15	14.69
VT3/DD	51.11	36.11	27.42	22.00	17.87	14.89	12.76
ANNUAL DD	911	1479	2193	3036	4016	5136	6417
PARAMETER A	.587	.603	.592	.580	.607	.641	.675
OFF SOUTH							
VTN/DD B1	-.472	-.472	-.472	-.472	.483	.483	.483
VTN/DD B2	-.108	-.108	-.108	-.108	-.110	-.110	-.110
A PARAM C1	.996	1.025	1.081	1.116	-1.748	-1.644	-1.545
A PARAM C2	.034	.039	.047	.058	.071	.076	.080

PATUXENT RIVER, MARYLAND LATITUDE = 38.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	95.07	63.91	46.15	35.59	28.85	24.13	20.70
VT2/DD	81.18	54.57	39.41	30.39	24.64	20.60	17.67
VT3/DD	70.50	47.39	34.22	26.39	21.39	17.89	15.35
ANNUAL DD	495	925	1512	2237	3098	4139	5363
PARAMETER A	.659	.662	.626	.606	.590	.594	.606
OFF SOUTH							
VTN/DD B1	-.216	-.216	-.216	-.216	-.216	-.216	-.216
VTN/DD B2	-.105	-.105	-.105	-.105	-.105	-.105	-.105
A PARAM C1	.225	.282	.339	.376	.412	.428	.418
A PARAM C2	.011	.019	.030	.039	.051	.062	.072

BOSTON, MASSACHUSETTS LATITUDE = 42.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	48.03	33.92	26.16	21.25	17.85	15.37	13.50
VT2/DD	41.05	28.99	22.36	18.16	15.25	13.14	11.54
VT3/DD	35.65	25.18	19.42	15.77	13.25	11.41	10.02
ANNUAL DD	1040	1717	2537	3508	4643	5949	7410
PARAMETER A	.690	.686	.691	.696	.706	.718	.731
OFF SOUTH							
VTN/DD B1	-2.360	-2.360	-2.360	-2.360	-2.360	-2.360	-2.360
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	2.894	3.259	3.486	3.643	3.749	3.827	3.882
A PARAM C2	.025	.031	.039	.047	.055	.063	.070

ALPENA, MICHIGAN LATITUDE = 45.0

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	16.81	12.80	10.34	8.67	7.46	6.55	5.84
VT2/DD	14.34	10.92	8.82	7.39	6.37	5.59	4.98
VT3/DD	12.45	9.48	7.65	6.42	5.53	4.85	4.32
ANNUAL DD	2433	3313	4337	5495	6777	8206	9780
PARAMETER A	.786	.906	.998	1.069	1.126	1.175	1.218
OFF SOUTH							
VTN/DD B1	.639	.639	.639	.639	.639	.639	.639
VTN/DD B2	-.096	-.096	-.096	-.096	-.096	-.096	-.096
A PARAM C1	-1.223	-.988	-.845	-.752	-.685	-.632	-.591
A PARAM C2	.014	.013	.013	.014	.015	.017	.018

DETROIT, MICHIGAN — LATITUDE = 42.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	36.34	25.50	19.42	15.59	12.94	11.04	9.63
VT2/DD	31.03	21.77	16.58	13.31	11.05	9.43	8.22
VT3/DD	26.94	18.90	14.40	11.55	9.59	8.19	7.14
ANNUAL DD	1429	2116	2923	3849	4915	6115	7469
PARAMETER A	.447	.551	.629	.700	.766	.825	.880
OFF SOUTH							
VTN/DD B1	.432	.432	.432	.432	.432	.432	.432
VTN/DD B2	-.101	-.101	-.101	-.101	-.101	-.101	-.101
A PARAM C1	-1.205	-.908	-.740	-.618	-.522	-.449	-.392
A PARAM C2	.055	.048	.045	.043	.041	.041	.041

FLINT, MICHIGAN — LATITUDE = 42.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	25.94	20.40	16.00	13.04	11.00	9.51	8.37
VT2/DD	22.16	17.42	13.66	11.14	9.39	8.12	7.15
VT3/DD	19.24	15.13	11.86	9.67	8.16	7.05	6.21
ANNUAL DD	1908	2681	3583	4617	5782	7101	8584
PARAMETER A	572	.563	.630	.697	.758	.816	.870
OFF SOUTH							
VTN/DD B1	.346	.346	.672	.672	.672	.672	.672
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	-.448	-.625	-1.562	-1.450	-1.352	-1.256	-1.169
A PARAM C2	.049	.054	.052	.050	.049	.049	.049

GRAND RAPIDS, MICHIGAN — LATITUDE = 42.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	26.31	19.22	15.14	12.49	10.63	9.25	8.19
VT2/DD	22.47	16.41	12.93	10.66	9.07	7.90	6.99
VT3/DD	19.51	14.25	11.22	9.26	7.88	6.86	6.07
ANNUAL DD	1793	2571	3469	4501	5654	6947	8393
PARAMETER A	.632	.727	.797	.860	.914	.965	1.011
OFF SOUTH							
VTN/DD B1	.845	.845	.845	.845	.845	.845	.845
VTN/DD B2	-.101	-.101	-.101	-.101	-.101	-.101	-.101
A PARAM C1	-1.631	-1.394	-1.253	-1.144	-1.063	-.995	-.940
A PARAM C2	.033	.031	.031	.031	.032	.032	.033

SAULT STE. MARIE, MICHIGAN — LATITUDE = 46.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	14.09	11.98	10.43	9.23	8.28	7.50	6.86
VT2/DD	12.04	10.25	8.92	7.89	7.08	6.42	5.87
VT3/DD	10.46	8.90	7.74	6.85	6.15	5.57	5.10
ANNUAL DD	3170	4119	5200	6444	7847	9407	11082
PARAMETER A	.823	.847	.875	.910	.944	.975	.996
OFF SOUTH							
VTN/DD B1	-.680	-.680	-.680	-.680	-.680	-.680	-.680
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	.889	.928	.940	.933	.922	.911	.911
A PARAM C2	.021	.023	.026	.028	.030	.033	.036

TRAVERSE CITY, MICHIGAN — LATITUDE = 44.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	18.70	14.83	12.29	10.49	9.15	8.11	7.29
VT2/DD	15.97	12.67	10.49	8.96	7.81	6.93	6.22
VT3/DD	13.87	11.00	9.11	7.78	6.78	6.01	5.40
ANNUAL DD	2161	3016	4003	5115	6357	7743	9277
PARAMETER A	.734	.755	.789	.822	.856	.890	.924
OFF SOUTH							
VTN/DD B1	.140	.140	.140	.140	.140	.140	.140
VTN/DD B2	-.101	-.101	-.101	-.101	-.101	-.101	-.101
A PARAM C1	.194	.209	.206	.196	.180	.164	.147
A PARAM C2	.031	.032	.033	.034	.035	.037	.039

DULUTH, MINNESOTA LATITUDE = 46.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	17.86	15.55	13.62	11.93	10.62	9.56	8.70
VT2/DD	15.30	13.33	11.68	10.24	9.11	8.21	7.47
VT3/DD	13.30	11.58	10.16	8.90	7.92	7.13	6.49
ANNUAL DD	3716	4704	5823	7081	8474	10013	11669
PARAMETER A	.610	.611	.637	.688	.734	.774	.803
OFF SOUTH							
VTN/DD B1	.167	.167	.909	.909	.909	.909	.909
VTN/DD B2	-.116	-.116	-.121	-.121	-.121	-.121	-.121
A PARAM C1	.493	.451	-1.780	-1.644	-1.535	-1.447	-1.391
A PARAM C2	.039	.046	.068	.068	.069	.071	.074

INTERNATIONAL FALLS, MINNESOTA LATITUDE = 48.3

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	14.11	12.38	10.83	9.61	8.62	7.82	7.15
VT2/DD	12.11	10.62	9.29	8.24	7.39	6.71	6.13
VT3/DD	10.52	9.23	8.07	7.16	6.43	5.83	5.33
ANNUAL DD	4331	5304	6402	7645	9040	10578	12229
PARAMETER A	.658	.690	.750	.810	.867	.916	.955
OFF SOUTH							
VTN/DD B1	-.023	.144	.144	.144	.144	.144	.144
VTN/DD B2	-.121	-.119	-.119	-.119	-.119	-.119	-.119
A PARAM C1	.369	-.078	-.075	-.080	-.088	-.096	-.104
A PARAM C2	.043	.039	.039	.039	.039	.041	.043

MINNEAPOLIS-ST. PAUL, MINNESOTA LATITUDE = 44.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	21.00	17.11	14.42	12.46	10.97	9.80	8.85
VT2/DD	17.98	14.65	12.35	10.67	9.39	8.39	7.58
VT3/DD	15.62	12.72	10.73	9.27	8.16	7.29	6.58
ANNUAL DD	2910	3731	4660	5706	6874	8179	9622
PARAMETER A	.645	.709	.768	.823	.873	.917	.957
OFF SOUTH							
VTN/DD B1	.088	.088	.088	.088	.088	.088	.088
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.112
A PARAM C1	-.078	-.033	.002	.029	.050	.067	.078
A PARAM C2	.022	.024	.025	.027	.028	.031	.033

ROCHESTER, MINNESOTA LATITUDE = 43.6

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	24.19	20.13	16.96	14.64	12.88	11.50	10.38
VT2/DD	20.72	17.24	14.53	12.55	11.04	9.85	8.89
VT3/DD	18.00	14.98	12.63	10.90	9.59	8.56	7.73
ANNUAL DD	2843	3699	4656	5720	6909	8248	9762
PARAMETER A	.577	.600	.645	.686	.726	.764	.801
OFF SOUTH							
VTN/DD B1	.124	.837	.837	.837	.837	.837	.837
VTN/DD B2	-.113	-.116	-.116	-.116	-.116	-.116	-.116
A PARAM C1	.695	-1.533	-1.393	-1.283	-1.196	-1.125	-1.069
A PARAM C2	.035	.051	.051	.053	.055	.057	.060

JACKSON, MISSISSIPPI LATITUDE = 32.2

DUE SOUTH	TR40 (M=12)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	405.80	201.84	113.56	72.30	50.76	38.30	30.40
VT2/DD	346.35	171.71	96.61	61.51	43.19	32.58	25.86
VT3/DD	300.82	149.05	83.86	53.39	37.49	28.28	22.45
ANNUAL DD	195	413	757	1238	1851	2600	3528
PARAMETER A	.423	.506	.592	.626	.638	.643	.654
OFF SOUTH							
VTN/DD B1	.290	-.455	-.455	-.455	-.455	-.455	-.455
VTN/DD B2	-.105	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	-1.745	1.055	.842	.754	.708	.674	.638
A PARAM C2	.065	.018	.022	.027	.033	.040	.048

MERIDIAN, MISSISSIPPI — LATITUDE = 32.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 2)	(M= 2)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	290.96	168.47	99.98	65.45	46.85	35.75	28.65
VT2/DD	245.42	142.10	85.03	55.66	39.85	30.40	24.37
VT3/DD	212.52	123.06	73.79	48.31	34.58	26.39	21.15
ANNUAL DD	243	474	825	1309	1950	2763	3747
PARAMETER A	.534	.466	.503	.562	.604	.624	.630
OFF SOUTH							
VTN/DD B1	.428	.428	.242	.242	.242	.242	.242
VTN/DD B2	-.067	-.067	-.092	-.092	-.092	-.092	-.092
A PARAM C1	-.296	-.397	.139	.078	.024	-.024	-.074
A PARAM C2	-.058	-.062	.036	.037	.039	.044	.053

COLUMBIA, MISSOURI — LATITUDE = 39.0

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	63.14	47.41	35.60	28.21	23.28	19.77	17.16
VT2/DD	53.99	40.54	30.47	24.14	19.92	16.92	14.69
VT3/DD	46.89	35.21	26.47	20.97	17.31	14.70	12.76
ANNUAL DD	1185	1750	2437	3243	4178	5263	6520
PARAMETER A	.465	.466	.525	.572	.609	.647	.682
OFF SOUTH							
VTN/DD B1	-.428	-.428	-.511	-.511	-.511	-.511	-.511
VTN/DD B2	-.112	-.112	-.115	-.115	-.115	-.115	-.115
A PARAM C1	.803	.948	1.219	1.187	1.167	1.136	1.106
A PARAM C2	.041	.047	.058	.059	.062	.065	.069

SPRINGFIELD, MISSOURI — LATITUDE = 37.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	104.39	69.82	51.24	40.01	32.58	27.28	23.43
VT2/DD	89.14	59.62	43.75	34.17	27.82	23.30	20.01
VT3/DD	77.42	51.78	38.00	29.67	24.16	20.23	17.38
ANNUAL DD	889	1403	2054	2833	3741	4790	6016
PARAMETER A	.404	.463	.477	.481	.485	.493	.505
OFF SOUTH							
VTN/DD B1	-.544	-.544	-.544	-.544	-.544	-.544	-.544
VTN/DD B2	-.106	-.106	-.106	-.106	-.106	-.106	-.106
A PARAM C1	.094	.078	.076	.072	.065	.068	.082
A PARAM C2	.049	.048	.054	.062	.072	.081	.092

ST. LOUIS, MISSOURI — LATITUDE = 38.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	64.17	45.27	34.06	26.96	22.16	18.78	16.29
VT2/DD	54.87	38.71	29.13	23.06	18.95	16.06	13.93
VT3/DD	47.66	33.62	25.30	20.03	16.46	13.95	12.10
ANNUAL DD	1068	1617	2290	3093	4020	5069	6257
PARAMETER A	.509	.574	.625	.662	.694	.721	.747
OFF SOUTH							
VTN/DD B1	-.981	-.981	-.981	-.981	-.981	-.981	-.981
VTN/DD B2	-.109	-.109	-.109	-.109	-.109	-.109	-.109
A PARAM C1	1.175	1.079	1.036	1.038	1.039	1.044	1.046
A PARAM C2	.045	.047	.048	.049	.051	.054	.058

BILLINGS, MONTANA — LATITUDE = 45.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	38.95	31.30	25.84	21.94	19.06	16.84	15.09
VT2/DD	33.45	26.88	22.19	18.85	16.37	14.47	12.96
VT3/DD	29.08	23.37	19.30	16.39	14.23	12.58	11.27
ANNUAL DD	2078	2844	3781	4865	6096	7464	8960
PARAMETER A	.640	.651	.663	.680	.699	.717	.730
OFF SOUTH							
VTN/DD B1	-.116	-.116	-.116	-.116	-.116	-.116	-.116
VTN/DD B2	-.126	-.126	-.126	-.126	-.126	-.126	-.126
A PARAM C1	-.066	.018	.091	.149	.193	.227	.254
A PARAM C2	.054	.062	.069	.074	.080	.086	.092

CUT BANK, MONTANA — LATITUDE = 48.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	28.42	23.76	19.98	17.12	14.96	13.27	11.92
VT2/DD	24.42	20.42	17.17	14.72	12.85	11.40	10.25
VT3/DD	21.24	17.75	14.93	12.80	11.18	9.92	8.91
ANNUAL DD	2884	3810	4914	6180	7597	9135	10772
PARAMETER A	.669	.695	.740	.785	.824	.852	.867
OFF SOUTH							
VTN/DD B1	-.004	-.004	-.004	-.004	-.004	-.004	-.004
VTN/DD B2	-.128	-.128	-.128	-.128	-.128	-.128	-.128
A PARAM C1	.154	.145	.128	.110	.095	.085	.080
A PARAM C2	.045	.052	.056	.059	.063	.068	.074

DILLON, MONTANA — LATITUDE = 45.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	42.69	33.97	27.93	23.69	20.57	18.18	16.28
VT2/DD	36.63	29.18	23.99	20.35	17.67	15.62	13.99
VT3/DD	31.84	25.37	20.86	17.69	15.36	13.58	12.16
ANNUAL DD	2374	3311	4404	5655	7058	8581	10195
PARAMETER A	.600	.623	.649	.667	.680	.684	.679
OFF SOUTH							
VTN/DD B1	.348	-.186	-.186	-.186	-.186	-.186	-.186
VTN/DD B2	-.122	-.127	-.127	-.127	-.127	-.127	-.127
A PARAM C1	-.686	.974	.978	.997	1.022	1.063	1.119
A PARAM C2	.050	.073	.080	.088	.096	.107	.120

GLASGOW, MONTANA — LATITUDE = 48.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	22.34	18.78	16.20	14.24	12.70	11.47	10.45
VT2/DD	19.15	16.10	13.89	12.21	10.89	9.83	8.96
VT3/DD	16.65	13.99	12.07	10.61	9.46	8.54	7.78
ANNUAL DD	3285	4180	5188	6329	7589	8984	10508
PARAMETER A	.719	.730	.750	.777	.804	.832	.858
OFF SOUTH							
VTN/DD B1	.409	.409	.409	.409	.409	.409	.409
VTN/DD B2	-.117	-.117	-.117	-.117	-.117	-.117	-.117
A PARAM C1	-.349	-.344	-.338	-.330	-.324	-.317	-.309
A PARAM C2	.027	.030	.032	.034	.037	.039	.043

GREAT FALLS, MONTANA — LATITUDE = 47.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	34.62	28.55	23.87	20.33	17.65	15.58	13.95
VT2/DD	29.69	24.49	20.47	17.44	15.14	13.36	11.96
VT3/DD	25.81	21.28	17.80	15.15	13.16	11.61	10.40
ANNUAL DD	2183	2940	3877	4994	6272	7697	9239
PARAMETER A	.812	.797	.781	.779	.784	.791	.794
OFF SOUTH							
VTN/DD B1	.271	.271	.271	.271	.271	.271	.271
VTN/DD B2	-.119	-.119	-.119	-.119	-.119	-.119	-.119
A PARAM C1	-.746	-.674	-.618	-.558	-.499	-.445	-.399
A PARAM C2	.033	.040	.047	.052	.058	.064	.070

HELENA, MONTANA — LATITUDE = 46.4

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	28.29	22.88	19.17	16.49	14.46	12.88	11.61
VT2/DD	24.23	19.60	16.42	14.12	12.39	11.03	9.95
VT3/DD	21.05	17.03	14.27	12.27	10.76	9.59	8.64
ANNUAL DD	2253	3124	4154	5334	6673	8148	9725
PARAMETER A	.755	.783	.806	.829	.851	.868	.876
OFF SOUTH							
VTN/DD B1	-.038	-.038	-.038	-.038	-.038	-.038	-.038
VTN/DD B2	-.114	-.114	-.114	-.114	-.114	-.114	-.114
A PARAM C1	.353	.340	.329	.319	.312	.310	.312
A PARAM C2	.020	.025	.031	.036	.041	.046	.052

LEWISTOWN, MONTANA — LATITUDE = 47.0

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	16.39	14.39	12.79	11.49	10.40	9.48	8.70
VT2/DD	13.76	12.08	10.74	9.65	8.73	7.96	7.31
VT3/DD	11.89	10.44	9.28	8.34	7.54	6.88	6.31
ANNUAL DD	6060	7241	8522	9877	11300	12771	14280
PARAMETER A	1.049	1.048	1.041	1.033	1.024	1.013	1.000
OFF SOUTH							
VTN/DD B1	-.164	-.164	-.164	-.164	-.164	-.164	-.164
VTN/DD B2	-.005	-.005	-.005	-.005	-.005	-.005	-.005
A PARAM C1	.173	.213	.255	.296	.335	.372	.406
A PARAM C2	-.018	-.021	-.024	-.026	-.026	-.026	-.026

MILES CITY, MONTANA — LATITUDE = 46.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	28.27	23.78	20.48	17.97	16.01	14.43	13.14
VT2/DD	24.26	20.41	17.57	15.42	13.74	12.38	11.27
VT3/DD	21.09	17.74	15.27	13.40	11.94	10.76	9.80
ANNUAL DD	2800	3655	4630	5717	6923	8259	9715
PARAMETER A	.693	.700	.705	.711	.721	.733	.744
OFF SOUTH							
VTN/DD B1	-.077	-.077	-.077	-.077	-.077	-.077	-.077
VTN/DD B2	-.122	-.122	-.122	-.122	-.122	-.122	-.122
A PARAM C1	1.105	1.110	1.107	1.097	1.074	1.044	1.014
A PARAM C2	.033	.039	.045	.051	.057	.063	.069

MISSOULA, MONTANA — LATITUDE = 46.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	21.10	15.51	12.27	10.14	8.65	7.54	6.68
VT2/DD	18.01	13.24	10.47	8.66	7.38	6.43	5.70
VT3/DD	15.63	11.50	9.09	7.52	6.41	5.58	4.95
ANNUAL DD	1770	2681	3765	5012	6409	7925	9541
PARAMETER A	.866	.950	1.017	1.076	1.125	1.163	1.189
OFF SOUTH							
VTN/DD B1	-.907	-.907	-.907	-.907	-.907	-.907	-.907
VTN/DD B2	-.099	-.099	-.099	-.099	-.099	-.099	-.099
A PARAM C1	1.003	.898	.829	.776	.738	.717	.709
A PARAM C2	.009	.011	.013	.015	.017	.019	.021

GRAND ISLAND, NEBRASKA — LATITUDE = 40.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	47.78	38.74	32.35	27.70	24.20	21.48	19.31
VT2/DD	40.93	33.18	27.71	23.73	20.72	18.40	16.54
VT3/DD	35.57	28.83	24.08	20.62	18.01	15.99	14.37
ANNUAL DD	1989	2717	3565	4535	5616	6829	8189
PARAMETER A	.529	.538	.544	.549	.552	.559	.565
OFF SOUTH							
VTN/DD B1	-.504	-.504	-.504	-.504	-.504	-.504	-.504
VTN/DD B2	-.117	-.117	-.117	-.117	-.117	-.117	-.117
A PARAM C1	1.034	1.089	1.126	1.148	1.158	1.147	1.129
A PARAM C2	.038	.046	.055	.064	.074	.085	.097

NORTH PLATTE, NEBRASKA — LATITUDE = 41.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	50.70	41.03	34.24	29.33	25.64	22.77	20.47
VT2/DD	43.42	35.14	29.33	25.12	21.96	19.50	17.53
VT3/DD	37.73	30.54	25.48	21.83	19.08	16.94	15.24
ANNUAL DD	2168	2958	3871	4900	6048	7336	8768
PARAMETER A	.623	.586	.563	.552	.551	.552	.552
OFF SOUTH							
VTN/DD B1	.106	.106	.106	.106	.106	.106	.106
VTN/DD B2	-.116	-.116	-.116	-.116	-.116	-.116	-.116
A PARAM C1	-.791	-.854	-.892	-.906	-.902	-.893	-.889
A PARAM C2	.045	.056	.066	.076	.086	.096	.109

OMAHA, NEBRASKA — LATITUDE = 41.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M=12)
VT1/DD	47.07	37.98	31.57	26.97	23.55	20.90	18.42
VT2/DD	40.28	32.50	27.01	23.08	20.15	17.88	15.78
VT3/DD	35.00	28.23	23.47	20.06	17.51	15.54	13.71
ANNUAL DD	1753	2397	3161	4051	5064	6197	7485
PARAMETER A	.473	.487	.502	.513	.522	.531	.570
OFF SOUTH							
VTN/DD B1	.122	.122	.122	.122	.122	.122	.252
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.118
A PARAM C1	.775	.724	.661	.596	.543	.498	-.004
A PARAM C2	.028	.034	.040	.046	.054	.062	.089

SCOTTSBLUFF, NEBRASKA — LATITUDE = 41.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	58.22	46.05	37.70	31.77	27.24	23.69	20.96
VT2/DD	49.87	39.45	32.30	27.22	23.38	20.34	17.99
VT3/DD	43.34	34.28	28.07	23.66	20.32	17.68	15.64
ANNUAL DD	2011	2806	3749	4813	6000	7328	8792
PARAMETER A	.585	.552	.532	.520	.515	.522	.526
OFF SOUTH							
VTN/DD B1	-.227	-.227	-.227	-.227	-.285	-.285	-.285
VTN/DD B2	-.117	-.117	-.117	-.117	-.125	-.125	-.125
A PARAM C1	.334	.401	.454	.500	.786	.807	.830
A PARAM C2	.052	.066	.080	.093	.137	.148	.160

ELKO, NEVADA — LATITUDE = 40.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	58.99	45.55	37.02	31.17	26.92	23.69	21.16
VT2/DD	50.62	39.08	31.76	26.75	23.10	20.33	18.15
VT3/DD	44.00	33.98	27.61	23.25	20.08	17.67	15.78
ANNUAL DD	1829	2693	3708	4872	6164	7570	9073
PARAMETER A	.793	.785	.772	.756	.736	.712	.684
OFF SOUTH							
VTN/DD B1	-.195	-.195	-.195	-.195	-.195	-.195	-.195
VTN/DD B2	-.124	-.124	-.124	-.124	-.124	-.124	-.124
A PARAM C1	.248	.351	.451	.548	.642	.734	.828
A PARAM C2	.039	.052	.066	.080	.096	.114	.134

ELY, NEVADA — LATITUDE = 39.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	64.22	50.47	41.28	34.87	30.17	26.59	23.77
VT2/DD	54.98	43.20	35.34	29.85	25.83	22.77	20.35
VT3/DD	47.77	37.54	30.71	25.93	22.44	19.78	17.68
ANNUAL DD	2202	3081	4107	5295	6622	8079	9642
PARAMETER A	.641	.634	.624	.613	.597	.574	.543
OFF SOUTH							
VTN/DD B1	-.580	-.580	-.580	-.580	-.580	-.580	-.580
VTN/DD B2	-.115	-.115	-.115	-.115	-.115	-.115	-.115
A PARAM C1	1.970	2.068	2.166	2.268	2.397	2.575	2.813
A PARAM C2	.057	.072	.088	.106	.126	.149	.178

LAS VEGAS, NEVADA — LATITUDE = 36.1

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	814.29	333.12	172.83	108.38	76.34	58.42	47.29
VT2/DD	697.07	285.56	148.15	92.91	65.44	50.08	40.54
VT3/DD	605.82	248.22	128.78	80.76	56.88	43.53	35.24
ANNUAL DD	131	332	664	1161	1831	2658	3625
PARAMETER A	.414	.435	.538	.590	.615	.617	.608
OFF SOUTH							
VTN/DD B1	.146	.273	.273	.273	.273	.273	.273
VTN/DD B2	-.119	-.123	-.123	-.123	-.123	-.123	-.123
A PARAM C1	.077	-.532	-.435	-.413	-.406	-.413	-.425
A PARAM C2	.016	.038	.034	.041	.055	.072	.092

LOVELOCK, NEVADA — LATITUDE = 40.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	92.15	6[illegible].14	54.19	44.04	36.97	31.83	27.92
VT2/DD	78.90	59.20	46.41	37.[illegible]	31.65	27.25	23.91
VT3/DD	68.57	51.45	40.33	32.77	27.51	23.68	20.78
ANNUAL DD	1322	1986	2818	3811	4953	6232	7627
PARAMETER A	.677	.681	.668	.652	.637	.622	.603
OFF SOUTH							
VTN/DD B1	-.226	-.226	-.226	-.226	-.226	-.226	-.226
VTN/DD B2	-.116	-.116	-.116	-.116	-.116	-.116	-.116
A PARAM C1	.681	.783	.888	.983	1.063	1.134	1.206
A PARAM C2	.019	.031	.047	.063	.081	.099	.120

RENO, NEVADA — LATITUDE = 39.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	106.87	75.31	56.67	45.03	37.16	31.60	27.49
VT2/DD	91.68	64.61	48.62	38.63	31.88	27.11	23.59
VT3/DD	79.70	56.16	42.26	33.58	27.71	23.57	20.50
ANNUAL DD	1162	1874	2771	3831	5052	6416	7893
PARAMETER A	.800	.768	.749	.730	.709	.681	.646
OFF SOUTH							
VTN/DD B1	.410	.410	.410	.410	.410	.410	.410
VTN/DD B2	-.124	-.124	-.124	-.124	-.124	-.124	-.124
A PARAM C1	-.271	-.337	-.389	-.437	-.483	-.533	-.587
A PARAM C2	.044	.061	.077	.094	.112	.133	.159

TONOPAH, NEVADA — LATITUDE = 38.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	122.69	89.97	68.65	54.46	45.13	38.53	33.61
VT2/DD	105.13	77.09	58.92	46.74	38.73	33.07	28.85
VT3/DD	91.38	67.01	51.22	40.63	33.67	28.75	25.08
ANNUAL DD	1166	1836	2664	3649	4783	6060	7472
PARAMETER A	.642	.595	.570	.558	.539	.519	.495
OFF SOUTH							
VTN/DD B1	-.132	-.132	.429	.429	.429	.429	.429
VTN/DD B2	-.120	-.120	-.126	-.126	-.126	-.126	-.126
A PARAM C1	.830	.955	-.847	-.841	-.848	-.857	-.874
A PARAM C2	.044	.066	.108	.129	.152	.177	.209

WINNEMUCCA, NEVADA — LATITUDE = 40.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	84.80	60.90	46.71	37.76	31.67	27.27	23.94
VT2/DD	72.64	52.16	40.01	32.34	27.13	23.36	20.51
VT3/DD	63.13	45.33	34.77	28.11	23.57	20.30	17.82
ANNUAL DD	1466	2228	3154	4236	5464	6811	8258
PARAMETER A	.700	.702	.702	.698	.686	.669	.648
OFF SOUTH							
VTN/DD B1	.007	.007	.007	.007	.007	.007	.007
VTN/DD B2	-.118	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	.522	.558	.579	.603	.631	.665	.703
A PARAM C2	.043	.055	.065	.077	.090	.106	.124

YUCCA FLATS, NEVADA — LATITUDE = 36.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	133.69	92.76	69.12	54.11	44.21	37.34	32.32
VT2/DD	114.63	79.54	59.27	46.40	37.91	32.02	27.71
VT3/DD	99.65	69.14	51.52	40.33	32.95	27.83	24.09
ANNUAL DD	906	1452	2152	3018	4043	5202	6486
PARAMETER A	.753	.742	.732	.712	.687	.658	.626
OFF SOUTH							
VTN/DD B1	.122	.122	.122	.122	.122	.122	.122
VTN/DD B2	-.124	-.124	-.124	-.124	-.124	-.124	-.124
A PARAM C1	.158	.181	.210	.242	.276	.310	.345
A PARAM C2	.050	.060	.073	.088	.105	.125	.147

AD-A136 329 PASSIVE SOLAR DESIGN PROCEDURES FOR NAVAL INSTALLATIONS 2/2
(U) LOS ALAMOS NATIONAL LAB NM W O WRAY ET AL. SEP 83
NCEL-CR-83.040 N68305-82-MP-20006

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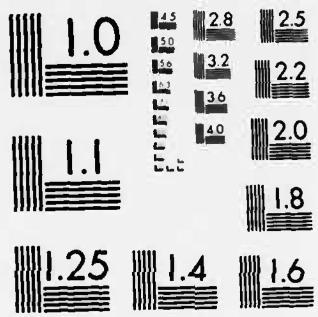

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CONCORD, NEW HAMPSHIRE LATITUDE = 43.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	23.53	18.43	15.09	12.75	11.02	9.70	8.66
VT2/DD	20.11	15.76	12.90	10.90	9.42	8.29	7.40
VT3/DD	17.47	13.69	11.20	9.47	8.18	7.20	6.43
ANNUAL DD	2149	2960	3909	4991	6213	7582	9092
PARAMETER A	.743	.806	.854	.892	.929	.960	.986
OFF SOUTH							
VTN/DD B1	.000	.000	.000	.000	.000	.000	.000
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	-.316	-.244	-.193	-.155	-.125	-.102	-.083
A PARAM C2	.026	.028	.030	.032	.034	.037	.040

LAKEHURST, NEW JERSEY LATITUDE = 40.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	62.01	44.39	34.17	27.54	21.88	18.10	15.41
VT2/DD	52.98	37.93	29.20	23.53	18.70	15.46	13.17
VT3/DD	46.01	32.94	25.36	20.43	16.24	13.43	11.44
ANNUAL DD	986	1584	2334	3232	4285	5497	6857
PARAMETER A	.585	.582	.570	.575	.648	.702	.746
OFF SOUTH							
VTN/DD B1	-.218	-.218	-.218	.413	.413	.413	.413
VTN/DD B2	-.107	-.107	-.107	-.106	-.106	-.106	-.106
A PARAM C1	.722	.835	.922	-.981	-.823	-.724	-.659
A PARAM C2	.039	.048	.059	.065	.065	.066	.068

NEWARK, NEW JERSEY LATITUDE = 40.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	68.92	47.20	35.20	27.92	23.10	19.66	17.12
VT2/DD	58.91	40.34	30.09	23.86	19.74	16.81	14.63
VT3/DD	51.17	35.04	26.13	20.73	17.15	14.60	12.71
ANNUAL DD	823	1400	2125	2982	3972	5105	6421
PARAMETER A	.524	.531	.532	.536	.548	.565	.590
OFF SOUTH							
VTN/DD B1	.236	.236	.236	.236	.236	.236	.236
VTN/DD B2	-.109	-.109	-.109	-.109	-.109	-.109	-.109
A PARAM C1	-.147	-.235	-.304	-.341	-.359	-.376	-.390
A PARAM C2	.033	.045	.055	.064	.072	.079	.086

ALBUQUERQUE, NEW MEXICO LATITUDE = 35.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	187.35	116.10	81.07	61.58	49.51	41.38	35.55
VT2/DD	160.10	99.21	69.28	52.62	42.31	35.36	30.38
VT3/DD	139.09	86.20	60.19	45.71	36.76	30.72	26.39
ANNUAL DD	753	1257	1925	2734	3677	4784	6074
PARAMETER A	.416	.468	.501	.508	.503	.501	.503
OFF SOUTH							
VTN/DD B1	.219	.219	.219	.219	.219	.219	.219
VTN/DD B2	-.110	-.110	-.110	-.110	-.110	-.110	-.110
A PARAM C1	.089	.069	.051	.041	.036	.038	.051
A PARAM C2	.068	.063	.066	.077	.093	.110	.130

CLAYTON, NEW MEXICO LATITUDE = 36.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	142.75	102.11	76.89	60.69	49.68	41.90	36.20
VT2/DD	122.32	87.50	65.88	52.00	42.57	35.90	31.02
VT3/DD	106.33	76.05	57.27	45.20	37.00	31.21	26.96
ANNUAL DD	1023	1561	2241	3062	4036	5191	6533
PARAMETER A	.447	.444	.437	.429	.422	.418	.411
OFF SOUTH							
VTN/DD B1	-.042	-.042	-.042	-.042	-.042	-.042	-.042
VTN/DD B2	-.119	-.119	-.119	-.119	-.119	-.119	-.119
A PARAM C1	.227	.276	.342	.413	.477	.540	.599
A PARAM C2	.105	.114	.126	.141	.162	.188	.219

ROSWELL, NEW MEXICO — LATITUDE = 33.2

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	216.84	138.09	97.26	73.39	58.06	47.60	40.16
VT2/DD	185.60	118.19	83.24	62.81	49.69	40.74	34.37
VT3/DD	161.30	102.72	72.35	54.59	43.19	35.41	29.87
ANNUAL DD	553	949	1488	2171	2990	3960	5101
PARAMETER A	.584	.581	.583	.572	.550	.532	.517
OFF SOUTH							
VTN/DD B1	-.353	-.353	-.353	-.353	-.353	-.353	-.353
VTN/DD B2	-.118	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	.468	.494	.528	.590	.669	.741	.802
A PARAM C2	.058	.064	.075	.090	.109	.130	.153

TRUTH OR CONSEQ., NEW MEXICO — LATITUDE = 33.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	199.58	133.29	95.42	72.22	57.28	47.19	40.07
VT2/DD	170.45	113.83	81.49	61.67	48.92	40.30	34.22
VT3/DD	148.09	98.90	70.80	53.59	42.50	35.02	29.73
ANNUAL DD	511	883	1394	2062	2888	3878	5050
PARAMETER A	.727	.700	.674	.650	.617	.584	.561
OFF SOUTH							
VTN/DD B1	.008	.008	.008	.008	.008	.008	.008
VTN/DD B2	-.110	-.110	-.110	-.110	-.110	-.110	-.110
A PARAM C1	.188	.257	.315	.367	.424	.484	.534
A PARAM C2	.012	.019	.027	.039	.057	.079	.103

TUCUMCARI, NEW MEXICO — LATITUDE = 35.1

DUE SOUTH	TR40 (M= 2)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	220.32	141.13	99.65	75.08	59.42	48.84	41.39
VT2/DD	186.77	120.60	85.15	64.16	50.78	41.73	35.37
VT3/DD	161.93	104.78	73.98	55.74	44.12	36.26	30.73
ANNUAL DD	693	1146	1735	2466	3339	4366	5573
PARAMETER A	.293	.346	.372	.382	.384	.385	.386
OFF SOUTH							
VTN/DD B1	.346	.139	.139	.139	.139	.139	.139
VTN/DD B2	-.084	-.110	-.110	-.110	-.110	-.110	-.110
A PARAM C1	-1.005	.049	-.008	-.050	-.082	-.109	-.133
A PARAM C2	-.080	.081	.089	.102	.121	.143	.169

ALBANY, NEW YORK — LATITUDE = 42.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	36.32	28.64	23.41	19.02	16.01	13.82	12.16
VT2/DD	31.09	24.52	20.03	16.27	13.70	11.82	10.40
VT3/DD	27.01	21.30	17.40	14.13	11.90	10.27	9.04
ANNUAL DD	1868	2645	3528	4519	5633	6886	8305
PARAMETER A	.556	.544	.554	.619	.673	.722	.769
OFF SOUTH							
VTN/DD B1	.081	.081	.172	.172	.172	.172	.172
VTN/DD B2	-.114	-.114	-.111	-.111	-.111	-.111	-.111
A PARAM C1	.192	.257	-.001	.035	.059	.074	.082
A PARAM C2	.057	.067	.061	.061	.062	.063	.065

BINGHAMTON, NEW YORK — LATITUDE = 42.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	18.45	14.15	11.42	9.53	8.13	7.07	6.25
VT2/DD	15.70	12.05	9.72	8.11	6.92	6.01	5.32
VT3/DD	13.62	10.45	8.43	7.04	6.00	5.22	4.61
ANNUAL DD	2172	3011	3950	5008	6199	7549	9071
PARAMETER A	.679	.753	.808	.861	.917	.974	1.028
OFF SOUTH							
VTN/DD B1	1.013	1.013	1.013	1.013	1.013	1.013	1.013
VTN/DD B2	-.087	-.087	-.087	-.087	-.087	-.087	-.087
A PARAM C1	-1.523	-1.402	-1.323	-1.248	-1.167	-1.086	-1.014
A PARAM C2	.019	.020	.021	.022	.023	.023	.024

BUFFALO, NEW YORK — LATITUDE = 42.6

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	22.01	16.39	12.55	10.13	8.47	7.26	6.36
VT2/DD	18.74	13.96	10.69	8.62	7.21	6.18	5.41
VT3/DD	16.26	12.11	9.27	7.48	6.25	5.36	4.70
ANNUAL DD	1684	2433	3321	4346	5515	6830	8306
PARAMETER A	.586	.641	.731	.806	.873	.933	.988
OFF SOUTH							
VTN/DD B1	.828	.314	.314	.314	.314	.314	.314
VTN/DD B2	-.088	-.088	-.088	-.088	-.088	-.088	-.088
A PARAM C1	-.768	.514	.395	.321	.265	.221	.186
A PARAM C2	.038	.035	.032	.030	.029	.029	.029

MASSENA, NEW YORK — LATITUDE = 44.6

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)
VT1/DD	20.22	16.89	14.50	12.70	11.30	10.07	9.02
VT2/DD	17.29	14.44	12.40	10.86	9.66	8.62	7.72
VT3/DD	15.02	12.54	10.77	9.43	8.39	7.49	6.71
ANNUAL DD	2746	3631	4640	5772	7030	8436	9985
PARAMETER A	.706	.720	.741	.762	.786	.822	.864
OFF SOUTH							
VTN/DD B1	-.178	-.178	-.178	-.178	-.178	.963	.963
VTN/DD B2	-.108	-.108	-.108	-.108	-.108	-.111	-.111
A PARAM C1	1.173	1.147	1.106	1.058	1.007	-1.351	-1.272
A PARAM C2	.028	.032	.035	.038	.041	.053	.054

NEW YORK (LA GUARDIA), NEW YORK — LATITUDE = 40.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M=12)
VT1/DD	66.42	45.08	33.45	26.52	21.90	18.62	16.02
VT2/DD	56.75	38.52	28.58	22.65	18.71	15.91	13.70
VT3/DD	49.28	33.45	24.82	19.67	16.25	13.82	11.90
ANNUAL DD	782	1328	2029	2861	3849	4998	6316
PARAMETER A	.557	.537	.541	.537	.546	.556	.584
OFF SOUTH							
VTN/DD B1	-.392	-.392	-.392	-.392	-.392	-.392	-.125
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.112
A PARAM C1	.931	1.007	1.031	1.074	1.080	1.080	.224
A PARAM C2	.037	.047	.055	.064	.073	.082	.106

NEW YORK (CENTAL PARK), NEW YORK — LATITUDE = 40.8

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)
VT1/DD	70.00	45.26	32.78	25.62	20.52	16.85	14.29
VT2/DD	59.89	38.72	28.04	21.92	17.57	14.42	12.23
VT3/DD	52.02	33.63	24.36	19.04	15.26	12.53	10.62
ANNUAL DD	781	1330	2041	2908	3914	5085	6473
PARAMETER A	.448	.459	.465	.487	.547	.622	.689
OFF SOUTH							
VTN/DD B1	-1.276	-1.276	-1.276	-1.276	-.431	-.431	-.431
VTN/DD B2	-.113	-.113	-.113	-.113	-.114	-.114	-.114
A PARAM C1	2.763	3.277	3.844	4.158	1.142	1.189	1.197
A PARAM C2	.063	.069	.074	.079	.081	.080	.081

ROCHESTER, NEW YORK — LATITUDE = 43.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	19.87	15.52	12.63	10.29	8.68	7.51	6.61
VT2/DD	16.93	13.22	10.77	8.77	7.40	6.40	5.64
VT3/DD	14.69	11.47	9.35	7.61	6.42	5.55	4.89
ANNUAL DD	1873	2656	3565	4608	5781	7110	8583
PARAMETER A	.644	.676	.719	.807	.879	.942	.997
OFF SOUTH							
VTN/DD B1	-.285	-.285	-.751	-.751	-.751	-.751	-.751
VTN/DD B2	-.090	-.090	-.094	-.094	-.094	-.094	-.094
A PARAM C1	-.809	-.751	.390	.353	.335	.326	.323
A PARAM C2	.022	.023	.035	.033	.032	.031	.032

SYRACUSE, NEW YORK — LATITUDE = 43.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	20.89	16.59	13.75	11.67	9.85	8.48	7.44
VT2/DD	17.81	14.14	11.72	9.95	8.39	7.23	6.34
VT3/DD	15.46	12.28	10.17	8.63	7.28	6.28	5.50
ANNUAL DD	1894	2641	3513	4512	5669	6983	8449
PARAMETER A	.578	.611	.643	.678	.755	.825	.887
OFF SOUTH							
VTN/DD B1	-.083	-.083	-.083	.130	.130	.130	.130
VTN/DD B2	-.094	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	-.251	-.268	-.270	-.772	-.673	-.593	-.529
A PARAM C2	.036	.037	.038	.037	.036	.035	.035

ASHEVILLE, NORTH CAROLINA — LATITUDE = 35.3

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	149.04	93.38	64.32	47.63	37.39	30.64	25.95
VT2/DD	126.19	79.07	54.45	40.33	31.66	25.94	21.97
VT3/DD	109.38	68.53	47.20	34.95	27.44	22.49	19.05
ANNUAL DD	655	1095	1668	2419	3372	4536	5936
PARAMETER A	.441	.449	.474	.486	.494	.505	.517
OFF SOUTH							
VTN/DD B1	.288	.288	.288	.288	.288	.288	.288
VTN/DD B2	-.078	-.078	-.078	-.078	-.078	-.078	-.078
A PARAM C1	-.785	-.827	-.820	-.851	-.903	-.943	-.977
A PARAM C2	-.041	-.034	-.027	-.019	-.008	.007	.026

CAPE HATTERAS, NORTH CAROLINA — LATITUDE = 35.3

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	416.30	207.61	121.41	81.01	57.85	43.11	34.09
VT2/DD	352.70	175.90	102.87	68.64	49.01	36.76	29.07
VT3/DD	305.79	152.50	89.18	59.51	42.49	31.92	25.24
ANNUAL DD	152	355	700	1212	1881	2739	3787
PARAMETER A	.529	.533	.458	.389	.383	.408	.434
OFF SOUTH							
VTN/DD B1	-.580	-.580	-.580	-.580	-.580	-.122	-.122
VTN/DD B2	-.082	-.082	-.082	-.082	-.082	-.100	-.100
A PARAM C1	.473	.573	.877	1.353	1.637	-.179	.003
A PARAM C2	-.047	-.044	-.046	-.040	-.023	.079	.094

CHARLOTTE, NORTH CAROLINA — LATITUDE = 35.1

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	164.16	106.26	75.30	55.28	42.39	33.88	27.94
VT2/DD	138.90	89.91	63.71	46.77	35.87	28.66	23.64
VT3/DD	120.37	77.92	55.22	40.53	31.08	24.84	20.49
ANNUAL DD	464	798	1265	1875	2641	3574	4708
PARAMETER A	.539	.509	.475	.468	.469	.483	.519
OFF SOUTH							
VTN/DD B1	.587	.587	.587	.587	.587	.587	.587
VTN/DD B2	-.073	-.073	-.073	-.073	-.073	-.073	-.073
A PARAM C1	-.847	-.990	-1.146	-1.233	-1.301	-1.320	-1.269
A PARAM C2	-.062	-.063	-.062	-.056	-.048	-.037	-.021

CHERRY POINT, NORTH CAROLINA — LATITUDE = 34.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	371.78	197.07	119.32	80.65	59.08	45.41	36.31
VT2/DD	317.15	168.11	101.79	68.80	50.40	38.74	30.98
VT3/DD	275.42	145.99	88.40	59.74	43.77	33.64	26.90
ANNUAL DD	184	412	764	1260	1899	2708	3732
PARAMETER A	.620	.560	.519	.484	.462	.454	.466
OFF SOUTH							
VTN/DD B1	-.657	-.657	-.657	-.657	-.657	-.657	-.657
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	.558	.888	1.120	1.328	1.494	1.626	1.687
A PARAM C2	.027	.034	.041	.053	.066	.080	.097

GREENSBORO, NORTH CAROLINA LATITUDE = 36.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 2)	(M= 2)	(M= 2)
VT1/DD	162.56	100.21	68.86	51.38	40.38	32.49	27.17
VT2/DD	138.78	85.55	58.79	43.86	34.19	27.51	23.01
VT3/DD	120.53	74.30	51.06	38.10	29.64	23.84	19.95
ANNUAL DD	515	929	1487	2183	3022	4023	5215
PARAMETER A	.513	.455	.444	.450	.470	.509	.539
OFF SOUTH							
VTN/DD B1	.737	.737	.737	.737	.416	.416	.416
VTN/DD B2	-.105	-.105	-.105	-.105	-.077	-.077	-.077
A PARAM C1	-.938	-1.171	-1.304	-1.386	-.069	-.176	-.281
A PARAM C2	.038	.049	.057	.064	-.038	-.024	-.009

RALEIGH-DURHAM, NORTH CAROLINA LATITUDE = 35.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 2)	(M= 2)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	151.96	99.67	63.67	44.84	33.74	26.80	22.16
VT2/DD	128.65	84.38	54.22	38.18	28.73	22.83	18.87
VT3/DD	111.53	73.15	47.06	33.14	24.94	19.81	16.38
ANNUAL DD	468	841	1346	1981	2780	3753	4910
PARAMETER A	.543	.437	.504	.554	.598	.626	.647
OFF SOUTH							
VTN/DD B1	.390	.390	-.362	-.362	-.362	-.362	-.362
VTN/DD B2	-.076	-.076	-.096	-.096	-.096	-.096	-.096
A PARAM C1	-1.097	-1.413	1.244	1.104	1.008	.955	.911
A PARAM C2	-.033	-.039	.040	.041	.044	.051	.059

BISMARCK, NORTH DAKOTA LATITUDE = 46.8

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	24.93	21.17	18.38	16.16	14.42	13.01	11.86
VT2/DD	21.36	18.14	15.75	13.87	12.37	11.17	10.18
VT3/DD	18.56	15.76	13.69	12.06	10.76	9.71	8.85
ANNUAL DD	3413	4330	5365	6522	7789	9166	10680
PARAMETER A	.564	.585	.611	.642	.670	.694	.717
OFF SOUTH							
VTN/DD B1	-.305	-.305	-.305	.314	.314	.314	.314
VTN/DD B2	-.115	-.115	-.115	-.121	-.121	-.121	-.121
A PARAM C1	.577	.606	.622	-1.145	-1.044	-.959	-.883
A PARAM C2	.038	.042	.046	.068	.071	.074	.078

FARGO, NORTH DAKOTA LATITUDE = 46.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	17.24	15.14	13.50	12.18	11.10	10.19	9.42
VT2/DD	14.78	12.98	11.58	10.44	9.51	8.74	8.08
VT3/DD	12.84	11.28	10.06	9.08	8.27	7.59	7.02
ANNUAL DD	3734	4643	5650	6775	8027	9408	10905
PARAMETER A	.677	.692	.712	.738	.768	.798	.823
OFF SOUTH							
VTN/DD B1	.432	.432	.432	.432	.432	.432	.432
VTN/DD B2	-.118	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	-.424	-.445	-.450	-.442	-.429	-.416	-.407
A PARAM C2	.031	.035	.038	.041	.044	.047	.050

MINOT, NORTH DAKOTA LATITUDE = 48.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	18.08	15.61	13.73	12.25	11.06	10.09	9.27
VT2/DD	15.51	13.39	11.78	10.51	9.49	8.65	7.95
VT3/DD	13.48	11.64	10.24	9.14	8.25	7.52	6.91
ANNUAL DD	3486	4426	5477	6641	7939	9373	10926
PARAMETER A	.731	.755	.777	.803	.830	.858	.881
OFF SOUTH							
VTN/DD B1	-.126	-.126	-.126	-.126	-.126	-.126	-.126
VTN/DD B2	-.120	-.120	-.120	-.120	-.120	-.120	-.120
A PARAM C1	.911	.895	.878	.856	.831	.806	.786
A PARAM C2	.027	.030	.034	.037	.040	.044	.047

AKRON-CANTON, OHIO — LATITUDE = 40.1

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	30.49	23.03	17.80	14.43	12.06	10.30	8.98
VT2/DD	26.02	19.65	15.18	12.32	10.29	8.79	7.66
VT3/DD	22.59	17.06	13.18	10.69	8.94	7.63	6.65
ANNUAL DD	1516	2204	3019	3977	5092	6358	7774
PARAMETER A	.563	.602	.684	.757	.823	.881	.930
OFF SOUTH							
VTN/DD B1	.106	.630	.630	.630	.630	.630	.630
VTN/DD B2	-.102	-.099	-.099	-.099	-.099	-.099	-.099
A PARAM C1	.862	-.732	-.660	-.604	-.562	-.529	-.506
A PARAM C2	.041	.036	.036	.036	.037	.038	.040

CINCINNATI, OHIO — LATITUDE = 39.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	40.12	30.18	23.73	19.42	16.34	14.08	12.36
VT2/DD	34.21	25.73	20.23	16.56	13.93	12.00	10.54
VT3/DD	29.69	22.34	17.56	14.37	12.09	10.42	9.15
ANNUAL DD	1055	1634	2335	3162	4126	5250	6563
PARAMETER A	.869	.817	.784	.764	.762	.774	.795
OFF SOUTH							
VTN/DD B1	-.755	-.755	-.755	-.755	-.755	-.755	-.755
VTN/DD B2	-.098	-.098	-.098	-.098	-.098	-.098	-.098
A PARAM C1	1.231	1.492	1.656	1.757	1.783	1.757	1.704
A PARAM C2	.021	.028	.033	.037	.041	.044	.048

COLUMBUS, OHIO — LATITUDE = 40.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M=12)	TR70 (M=12)
VT1/DD	40.68	29.89	23.32	19.01	16.01	13.46	11.60
VT2/DD	34.69	25.49	19.89	16.21	13.65	11.49	9.90
VT3/DD	30.11	22.13	17.27	14.07	11.85	9.98	8.60
ANNUAL DD	1216	1832	2576	3462	4507	5722	7112
PARAMETER A	.615	.605	.611	.628	.654	.716	.772
OFF SOUTH							
VTN/DD B1	.268	.268	.268	.268	.268	.816	.816
VTN/DD B2	-.098	-.098	-.098	-.098	-.098	-.101	-.101
A PARAM C1	.696	.718	.705	.668	.613	-.750	-.703
A PARAM C2	.034	.037	.040	.043	.046	.054	.055

DAYTON, OHIO — LATITUDE = 39.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	37.59	27.15	20.95	16.86	14.02	11.97	10.44
VT2/DD	32.06	23.16	17.87	14.38	11.95	10.21	8.90
VT3/DD	27.83	20.10	15.52	12.48	10.38	8.86	7.73
ANNUAL DD	1315	1935	2678	3559	4572	5729	7063
PARAMETER A	.655	.707	.746	.788	.827	.867	.912
OFF SOUTH							
VTN/DD B1	.667	.667	.667	.667	.667	.667	.667
VTN/DD B2	-.098	-.098	-.098	-.098	-.098	-.098	-.098
A PARAM C1	-.979	-.858	-.774	-.701	-.645	-.599	-.558
A PARAM C2	.026	.028	.030	.031	.033	.034	.036

TOLEDO, OHIO — LATITUDE = 41.4

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	29.31	21.70	17.04	13.87	11.66	10.05	8.83
VT2/DD	25.01	18.52	14.54	11.83	9.95	8.57	7.53
VT3/DD	21.71	16.08	12.62	10.27	8.63	7.44	6.54
ANNUAL DD	1644	2373	3242	4235	5364	6637	8071
PARAMETER A	.700	.761	.821	.882	.933	.978	1.019
OFF SOUTH							
VTN/DD B1	.645	.645	.645	.645	.645	.645	.645
VTN/DD B2	-.100	-.100	-.100	-.100	-.100	-.100	-.100
A PARAM C1	-1.689	-1.538	-1.381	-1.233	-1.118	-1.025	-.949
A PARAM C2	.023	.024	.025	.025	.026	.028	.030

YOUNGSTOWN, OHIO — LATITUDE = 41.2

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	27.09	21.14	16.09	12.83	10.62	9.04	7.86
VT2/DD	22.87	17.85	13.71	10.93	9.05	7.70	6.70
VT3/DD	19.81	15.46	11.90	9.48	7.85	6.68	5.82
ANNUAL DD	1688	2396	3256	4271	5423	6727	8209
PARAMETER A	.490	.519	.620	.717	.795	.864	.926
OFF SOUTH							
VTN/DD B1	.749	.749	.564	.564	.564	.564	.564
VTN/DD B2	-.054	-.054	-.093	-.093	-.093	-.093	-.093
A PARAM C1	-.085	-.155	.089	.039	.006	-.016	-.034
A PARAM C2	-.073	-.065	.049	.044	.041	.040	.040

OKLAHOMA CITY, OKLAHOMA — LATITUDE = 35.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	120.62	84.75	62.65	48.67	39.38	32.97	28.32
VT2/DD	103.00	72.38	53.50	41.56	33.63	28.15	24.18
VT3/DD	89.48	62.87	46.48	36.10	29.21	24.46	21.01
ANNUAL DD	688	1111	1652	2322	3145	4120	5246
PARAMETER A	.475	.459	.451	.452	.469	.481	.483
OFF SOUTH							
VTN/DD B1	-.381	-.381	-.381	-.381	-.381	-.381	-.381
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	1.370	1.455	1.471	1.441	1.344	1.260	1.206
A PARAM C2	.056	.063	.068	.072	.077	.087	.102

TULSA, OKLAHOMA — LATITUDE = 36.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	119.05	79.27	57.93	45.07	36.52	30.56	26.21
VT2/DD	101.74	67.75	49.50	38.52	31.21	26.11	22.40
VT3/DD	88.38	58.85	43.00	33.46	27.11	22.68	19.46
ANNUAL DD	658	1079	1618	2270	3050	3964	5022
PARAMETER A	.468	.495	.491	.474	.467	.468	.475
OFF SOUTH							
VTN/DD B1	.670	.670	.670	.670	.670	.670	.670
VTN/DD B2	-.109	-.109	-.109	-.109	-.109	-.109	-.109
A PARAM C1	-1.948	-1.880	-1.956	-2.078	-2.145	-2.171	-2.179
A PARAM C2	.050	.054	.063	.074	.085	.095	.106

ASTORIA, OREGON — LATITUDE = 46.1

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	145.46	69.32	38.47	23.76	17.01	13.25	10.85
VT2/DD	124.27	59.22	32.86	20.30	14.54	11.32	9.27
VT3/DD	107.91	51.42	28.54	17.62	12.62	9.83	8.05
ANNUAL DD	192	529	1212	2271	3671	5330	7104
PARAMETER A	.712	.791	.847	.907	.975	1.023	1.035
OFF SOUTH							
VTN/DD B1	.207	.207	.207	.207	.207	.207	.207
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	-.202	-.212	-.259	-.280	-.297	-.339	-.403
A PARAM C2	.020	.028	.039	.044	.047	.050	.056

MEDFORD, OREGON — LATITUDE = 42.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	54.15	30.50	20.33	15.15	12.07	10.03	8.58
VT2/DD	46.16	26.00	17.33	12.91	10.29	8.55	7.31
VT3/DD	40.06	22.56	15.04	11.21	8.93	7.42	6.35
ANNUAL DD	543	1120	1933	2954	4159	5516	6996
PARAMETER A	1.093	1.174	1.223	1.251	1.278	1.302	1.321
OFF SOUTH							
VTN/DD B1	-1.803	-1.803	-1.803	-1.803	-1.803	-1.803	-1.803
VTN/DD B2	-.094	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	.799	.697	.660	.654	.649	.646	.650
A PARAM C2	.005	.006	.008	.011	.013	.016	.019

NORTH BEND, OREGON — LATITUDE = 43.3

DUE SOUTH	TR40 (M=12)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	484.07	182.09	88.71	49.06	31.43	23.05	18.20
VT2/DD	413.66	155.63	75.82	41.92	26.86	19.70	15.56
VT3/DD	359.21	135.15	65.84	36.40	23.32	17.11	13.51
ANNUAL DD	83	293	791	1720	3120	4808	6613
PARAMETER A	.543	.722	.730	.831	.945	.961	.940
OFF SOUTH							
VTN/DD B1	.096	.163	.163	.096	.096	.096	.096
VTN/DD B2	-.105	-.106	-.106	-.105	-.105	-.105	-.105
A PARAM C1	-.033	-.454	-.757	-.701	-.712	-.823	-.955
A PARAM C2	.010	.031	.048	.050	.054	.065	.077

PORTLAND, OREGON — LATITUDE = 45.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	86.62	40.06	23.47	16.11	12.21	9.83	8.23
VT2/DD	73.55	34.02	19.92	13.68	10.37	8.35	6.98
VT3/DD	63.77	29.50	17.28	11.86	8.99	7.24	6.06
ANNUAL DD	251	639	1313	2255	3465	4910	6511
PARAMETER A	.787	.941	1.006	1.061	1.123	1.183	1.223
OFF SOUTH							
VTN/DD B1	-.831	-.831	-.831	-.831	-.831	-.831	-.831
VTN/DD B2	-.076	-.076	-.076	-.076	-.076	-.076	-.076
A PARAM C1	.941	.749	.713	.680	.626	.566	.522
A PARAM C2	-.015	-.010	-.008	-.005	-.002	.001	.004

REDMOND, OREGON — LATITUDE = 44.2

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	73.60	48.94	35.38	27.46	22.37	18.87	16.31
VT2/DD	63.08	41.94	30.32	23.53	19.17	16.17	13.98
VT3/DD	54.82	36.45	26.35	20.45	16.66	14.05	12.15
ANNUAL DD	1115	1862	2859	4065	5430	6922	8507
PARAMETER A	.796	.838	.845	.846	.843	.834	.820
OFF SOUTH							
VTN/DD B1	.254	.254	.254	.254	.254	.254	.254
VTN/DD B2	-.117	-.117	-.117	-.117	-.117	-.117	-.117
A PARAM C1	.500	.532	.571	.589	.594	.593	.594
A PARAM C2	.041	.047	.055	.064	.073	.083	.094

SALEM, OREGON — LATITUDE = 44.6

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	130.26	61.05	31.30	19.75	14.35	11.26	9.27
VT2/DD	110.98	51.98	26.64	16.82	12.22	9.59	7.89
VT3/DD	96.31	45.09	23.12	14.59	10.60	8.32	6.84
ANNUAL DD	260	650	1391	2474	3790	5277	6886
PARAMETER A	.880	.953	1.049	1.116	1.161	1.193	1.213
OFF SOUTH							
VTN/DD B1	.045	-.528	-.528	-.528	-.528	-.528	-.528
VTN/DD B2	-.092	-.088	-.088	-.088	-.088	-.088	-.088
A PARAM C1	-.427	.400	.344	.321	.303	.288	.277
A PARAM C2	.013	.012	.013	.015	.017	.019	.022

ALLENTOWN, PENNSYLVANIA — LATITUDE = 40.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	43.98	32.90	25.64	20.44	16.97	14.48	12.63
VT2/DD	37.57	28.11	21.91	17.46	14.50	12.37	10.79
VT3/DD	32.63	24.41	19.02	15.17	12.59	10.75	9.37
ANNUAL DD	1357	2032	2807	3705	4759	5976	7373
PARAMETER A	.507	.505	.530	.590	.650	.704	.753
OFF SOUTH							
VTN/DD B1	.280	.280	.571	.571	.571	.571	.571
VTN/DD B2	-.107	-.107	-.105	-.105	-.105	-.105	-.105
A PARAM C1	.479	.485	-.526	-.479	-.451	-.444	-.447
A PARAM C2	.047	.056	.058	.057	.057	.059	.061

ERIE, PENNSYLVANIA LATITUDE = 42.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	27.59	20.77	16.15	12.87	10.66	9.09	7.92
VT2/DD	23.52	17.70	13.79	10.98	9.10	7.75	6.76
VT3/DD	20.41	15.36	11.97	9.53	7.90	6.73	5.86
ANNUAL DD	1530	2254	3111	4099	5234	6532	8014
PARAMETER A	.600	.613	.655	.727	.794	.860	.923
DFF SOUTH							
VTN/DD B1	.124	.124	.335	.335	.335	.335	.335
VTN/DD B2	-.094	-.094	-.100	-.100	-.100	-.100	-.100
A PARAM C1	-.518	-.529	-1.033	-.899	-.792	-.705	-.632
A PARAM C2	.033	.038	.058	.054	.051	.049	.047

HARRISBURG, PENNSYLVANIA LATITUDE = 40.1

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	53.07	37.33	28.49	22.98	19.24	16.53	14.49
VT2/DD	45.32	31.88	24.34	19.63	16.43	14.12	12.38
VT3/DD	39.35	27.68	21.13	17.04	14.27	12.26	10.75
ANNUAL DD	985	1635	2415	3290	4274	5410	6734
PARAMETER A	.643	.652	.633	.613	.606	.622	.650
DFF SOUTH							
VTN/DD B1	-.502	-.502	-.502	-.502	-.502	-.502	-.502
VTN/DD B2	-.105	-.105	-.105	-.105	-.105	-.105	-.105
A PARAM C1	1.106	1.174	1.292	1.392	1.439	1.415	1.355
A PARAM C2	.032	.038	.048	.057	.065	.069	.073

PHILADELPHIA, PENNSYLVANIA LATITUDE = 39.5

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	63.23	44.06	33.24	26.49	21.95	18.69	16.27
VT2/DD	54.00	37.63	28.38	22.62	18.74	15.96	13.89
VT3/DD	46.89	32.67	24.65	19.64	16.28	13.86	12.06
ANNUAL DD	865	1449	2171	3013	3982	5112	6412
PARAMETER A	.669	.648	.632	.621	.616	.625	.642
DFF SOUTH							
VTN/DD B1	.044	.044	.044	.044	.044	.044	.044
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	-.302	-.231	-.167	-.114	-.068	-.030	-.006
A PARAM C2	.019	.027	.036	.046	.055	.063	.069

PITTSBURGH, PENNSYLVANIA LATITUDE = 40.3

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M=12)	(M=12)	(M=12)	(M=12)	(M=12)
VT1/DD	33.34	25.63	19.41	15.27	12.51	10.56	9.13
VT2/DD	28.45	21.86	16.54	13.01	10.66	9.00	7.78
VT3/DD	24.70	18.98	14.35	11.29	9.25	7.81	6.75
ANNUAL DD	1453	2118	2899	3812	4881	6120	7539
PARAMETER A	.574	.542	.602	.669	.734	.801	.866
DFF SOUTH							
VTN/DD B1	.549	.549	-.085	-.085	-.085	-.085	-.085
VTN/DD B2	-.100	-.100	-.093	-.093	-.093	-.093	-.093
A PARAM C1	-1.283	-1.386	.579	.509	.450	.396	.353
A PARAM C2	.059	.067	.040	.039	.037	.037	.037

WILKES-BARRE, PENNSYLVANIA LATITUDE = 41.2

	TR40	TR45	TR50	TR55	TR60	TR65	TR70
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	32.26	24.38	19.42	16.12	13.78	12.04	10.68
VT2/DD	27.49	20.78	16.55	13.74	11.75	10.26	9.11
VT3/DD	23.86	18.03	14.36	11.92	10.20	8.90	7.90
ANNUAL DD	1468	2180	3032	4019	5134	6407	7853
PARAMETER A	.614	.617	.636	.659	.688	.723	.756
DFF SOUTH							
VTN/DD B1	-.301	-.301	-.301	-.301	-.301	-.301	-.301
VTN/DD B2	-.094	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	.687	.690	.657	.615	.568	.519	.477
A PARAM C2	.015	.021	.026	.030	.034	.038	.042

PROVIDENCE, RHODE ISLAND — LATITUDE = 41.4

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	52.85	37.14	28.06	22.18	18.26	15.47	13.42
VT2/DD	45.23	31.79	24.01	18.99	15.63	13.24	11.48
VT3/DD	39.29	27.62	20.86	16.49	13.57	11.50	9.98
ANNUAL DD	1218	1899	2733	3729	4864	6147	7594
PARAMETER A	.439	.508	.567	.621	.661	.698	.734
OFF SOUTH							
VTN/DD B1	.189	.189	.189	.189	.189	.189	.189
VTN/DD B2	-.113	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	-.601	-.519	-.481	-.450	-.431	-.408	-.382
A PARAM C2	.064	.069	.071	.073	.076	.078	.081

CHARLESTON, SOUTH CAROLINA — LATITUDE = 32.8

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	466.60	245.59	141.31	89.85	61.32	44.69	34.59
VT2/DD	397.80	209.38	120.47	76.60	52.28	38.10	29.49
VT3/DD	345.43	181.81	104.61	66.51	45.40	33.08	25.61
ANNUAL DD	148	324	627	1065	1652	2406	3362
PARAMETER A	.578	.573	.556	.543	.554	.579	.604
OFF SOUTH							
VTN/DD B1	.270	.270	.270	.270	.270	.270	.270
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	.220	.290	.340	.390	.417	.434	.439
A PARAM C2	.016	.023	.030	.038	.044	.050	.060

COLUMBIA, SOUTH CAROLINA — LATITUDE = 33.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	215.30	120.76	78.23	56.20	42.80	33.81	27.57
VT2/DD	183.34	102.83	66.62	47.86	36.44	28.79	23.48
VT3/DD	159.15	89.27	57.83	41.55	31.64	24.99	20.38
ANNUAL DD	289	554	942	1461	2123	2942	3946
PARAMETER A	.819	.794	.750	.722	.705	.703	.714
OFF SOUTH							
VTN/DD B1	-.072	-.072	-.072	-.072	-.072	-.072	-.072
VTN/DD B2	-.096	-.096	-.096	-.096	-.096	-.096	-.096
A PARAM C1	.490	.547	.629	.659	.652	.613	.558
A PARAM C2	.007	.010	.013	.016	.020	.027	.035

GREENVILLE, SOUTH CAROLINA — LATITUDE = 34.5

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	186.96	119.62	82.97	60.06	44.18	34.36	28.01
VT2/DD	158.35	101.31	70.27	50.87	37.75	29.35	23.93
VT3/DD	137.28	87.83	60.92	44.10	32.79	25.50	20.78
ANNUAL DD	381	683	1110	1720	2518	3496	4659
PARAMETER A	.410	.414	.405	.430	.495	.546	.570
OFF SOUTH							
VTN/DD B1	-.114	-.114	-.114	-.114	-.107	-.107	-.107
VTN/DD B2	-.081	-.081	-.081	-.081	-.108	-.108	-.108
A PARAM C1	.513	.518	.557	.541	.469	.404	.365
A PARAM C2	-.060	-.054	-.050	-.039	.075	.083	.096

HURON, SOUTH DAKOTA — LATITUDE = 44.2

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	19.58	16.31	13.95	12.18	10.81	9.72	8.82
VT2/DD	16.76	13.96	11.94	10.43	9.26	8.32	7.55
VT3/DD	14.57	12.13	10.38	9.06	8.04	7.23	6.56
ANNUAL DD	3149	4011	4985	6072	7273	8588	10028
PARAMETER A	.739	.802	.856	.904	.943	.977	1.007
OFF SOUTH							
VTN/DD B1	-.200	-.200	-.200	-.200	-.200	-.200	-.200
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.112
A PARAM C1	.015	.041	.066	.090	.113	.134	.152
A PARAM C2	.021	.021	.023	.025	.027	.030	.033

PIERRE, SOUTH DAKOTA — LATITUDE = 44.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	32.52	26.96	23.03	20.09	17.82	16.01	14.53
VT2/DD	27.88	23.12	19.74	17.22	15.27	13.72	12.46
VT3/DD	24.23	20.09	17.15	14.97	13.27	11.93	10.83
ANNUAL DD	2496	3299	4212	5243	6395	7667	9072
PARAMETER A	.578	.593	.607	.625	.645	.664	.682
OFF SOUTH							
VTN/DD B1	.240	.240	.240	.240	.240	.240	.240
VTN/DD B2	-.119	-.119	-.119	-.119	-.119	-.119	-.119
A PARAM C1	.019	.040	.056	.065	.071	.074	.074
A PARAM C2	.036	.042	.048	.053	.059	.066	.072

RAPID CITY, SOUTH DAKOTA — LATITUDE = 44.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	47.93	37.94	30.98	25.88	22.21	19.45	17.29
VT2/DD	41.10	32.53	26.60	22.22	19.07	16.70	14.84
VT3/DD	35.72	28.27	23.12	19.32	16.58	14.51	12.91
ANNUAL DD	2159	2958	3903	4980	6185	7529	9009
PARAMETER A	.527	.527	.545	.573	.596	.616	.630
OFF SOUTH							
VTN/DD B1	.249	.249	.837	.837	.837	.837	.837
VTN/DD B2	-.120	-.120	-.124	-.124	-.124	-.124	-.124
A PARAM C1	.786	.805	-1.310	-1.228	-1.169	-1.122	-1.088
A PARAM C2	.050	.059	.082	.088	.094	.102	.110

SIOUX FALLS, SOUTH DAKOTA — LATITUDE = 43.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	29.73	24.86	21.36	18.72	16.66	15.01	13.66
VT2/DD	25.48	21.30	18.30	16.04	14.27	12.86	11.70
VT3/DD	22.14	18.51	15.90	13.94	12.41	11.18	10.17
ANNUAL DD	2661	3500	4439	5487	6644	7924	9349
PARAMETER A	.688	.690	.698	.713	.724	.734	.744
OFF SOUTH							
VTN/DD B1	-.610	-.610	-.610	-.610	-.610	-.610	-.610
VTN/DD B2	-.117	-.117	-.117	-.117	-.117	-.117	-.117
A PARAM C1	1.776	1.869	1.905	1.903	1.898	1.888	1.866
A PARAM C2	.027	.032	.037	.042	.049	.056	.063

CHATTANOOGA, TENNESSEE — LATITUDE = 35.0

DUE SOUTH	TR40 (M= 2)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	138.13	86.06	55.92	40.50	31.19	25.08	20.91
VT2/DD	116.79	73.43	47.72	34.56	26.61	21.40	17.84
VT3/DD	101.20	63.75	41.43	30.01	23.11	18.58	15.49
ANNUAL DD	510	925	1483	2154	2949	3895	5035
PARAMETER A	.454	.433	.508	.545	.573	.601	.637
OFF SOUTH							
VTN/DD B1	-.149	-.024	-.024	-.024	-.024	-.024	-.024
VTN/DD B2	-.071	-.102	-.102	-.102	-.102	-.102	-.102
A PARAM C1	.399	-.111	-.169	-.219	-.259	-.293	-.319
A PARAM C2	-.054	.073	.063	.063	.066	.070	.074

KNOXVILLE, TENNESSEE — LATITUDE = 35.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	94.64	66.94	49.39	38.02	30.23	24.91	21.13
VT2/DD	80.69	57.07	42.11	32.41	25.77	21.24	18.02
VT3/DD	70.05	49.55	36.56	28.14	22.38	18.44	15.64
ANNUAL DD	584	974	1515	2196	3028	4004	5162
PARAMETER A	.676	.614	.577	.550	.541	.539	.559
OFF SOUTH							
VTN/DD B1	-.141	-.141	-.141	-.141	-.141	-.141	-.141
VTN/DD B2	-.100	-.100	-.100	-.100	-.100	-.100	-.100
A PARAM C1	.055	-.000	-.059	-.109	-.145	-.172	-.185
A PARAM C2	.020	.028	.037	.047	.055	.064	.073

MEMPHIS, TENNESSEE — LATITUDE = 35.0

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	186.42	104.84	68.64	49.17	37.72	30.23	25.08
VT2/DD	158.81	89.31	58.47	41.89	32.13	25.75	21.36
VT3/DD	137.86	77.53	50.76	36.36	27.89	22.36	18.54
ANNUAL DD	372	700	1162	1767	2493	3358	4371
PARAMETER A	.558	.538	.523	.526	.533	.551	.567
OFF SOUTH							
VTN/DD B1	-.057	-.057	-.057	-.057	-.057	-.057	-.057
VTN/DD B2	-.097	-.097	-.097	-.097	-.097	-.097	-.097
A PARAM C1	.142	.134	.144	.159	.174	.190	.208
A PARAM C2	.024	.029	.034	.036	.040	.044	.051

NASHVILLE, TENNESSEE — LATITUDE = 36.1

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	126.16	78.15	53.54	39.31	30.46	24.35	20.28
VT2/DD	107.62	66.78	45.75	33.60	25.98	20.78	17.30
VT3/DD	93.43	58.00	39.74	29.18	22.56	18.04	15.02
ANNUAL DD	500	874	1374	2018	2803	3742	4880
PARAMETER A	.411	.483	.533	.560	.579	.605	.627
OFF SOUTH							
VTN/DD B1	-.099	.321	.321	.321	-.099	-.099	-.099
VTN/DD B2	-.103	-.109	-.109	-.109	-.103	-.103	-.103
A PARAM C1	1.737	-.271	-.387	-.483	.725	.620	.533
A PARAM C2	.037	.064	.065	.069	.054	.059	.066

ABILENE, TEXAS — LATITUDE = 32.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	238.34	148.85	102.07	74.46	57.27	45.97	38.15
VT2/DD	203.63	127.17	87.21	63.61	48.93	39.27	32.59
VT3/DD	176.92	110.49	75.77	55.27	42.51	34.12	28.32
ANNUAL DD	326	610	1024	1562	2224	3032	3989
PARAMETER A	.682	.648	.586	.543	.527	.521	.511
OFF SOUTH							
VTN/DD B1	-.446	-.446	-.446	-.446	-.446	-.446	-.446
VTN/DD B2	-.109	-.109	-.109	-.109	-.109	-.109	-.109
A PARAM C1	.019	.009	.009	.014	.021	.033	.063
A PARAM C2	.030	.041	.054	.067	.077	.089	.107

AMARILLO, TEXAS — LATITUDE = 35.1

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	170.78	113.65	81.91	62.65	50.00	41.28	35.09
VT2/DD	144.84	96.38	69.47	53.13	42.41	35.01	29.76
VT3/DD	125.58	83.57	60.23	46.07	36.77	30.36	25.80
ANNUAL DD	829	1333	1976	2756	3671	4732	5973
PARAMETER A	.426	.429	.444	.455	.461	.469	.477
OFF SOUTH							
VTN/DD B1	-.077	-.077	-.077	-.077	-.077	-.077	-.077
VTN/DD B2	-.086	-.086	-.086	-.086	-.086	-.086	-.086
A PARAM C1	-.139	-.089	-.042	-.000	.039	.072	.100
A PARAM C2	-.048	-.037	-.024	-.011	.005	.023	.042

AUSTIN, TEXAS — LATITUDE = 30.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	1210.9	446.81	210.02	121.91	82.15	60.25	46.75
VT2/DD	1031.1	380.46	178.83	103.80	69.95	51.31	39.80
VT3/DD	895.38	330.36	155.28	90.14	60.74	44.55	34.56
ANNUAL DD	73	215	484	870	1378	2026	2847
PARAMETER A	.498	.438	.412	.413	.415	.423	.428
OFF SOUTH							
VTN/DD B1	.053	.053	.053	.053	.053	.053	.053
VTN/DD B2	-.098	-.098	-.098	-.098	-.098	-.098	-.098
A PARAM C1	-1.724	-2.001	-2.109	-2.075	-2.019	-1.943	-1.901
A PARAM C2	.065	.068	.068	.068	.073	.081	.096

BROWNSVILLE, TEXAS — LATITUDE = 25.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	1434.3	562.04	282.25	161.86	102.78	68.42
VT2/DD	NA	1216.1	476.53	239.31	137.24	87.14	58.01
VT3/DD	NA	1055.2	413.52	207.66	119.09	75.62	50.34
ANNUAL DD	NA	35	108	247	466	798	1295
PARAMETER A	NA	.319	.489	.458	.424	.440	.494
OFF SOUTH							
VTN/DD B1	NA	.477	.477	.477	.477	.477	.477
VTN/DD B2	NA	-.085	-.085	-.085	-.085	-.085	-.085
A PARAM C1	NA	-.673	-.337	-.206	-.135	-.034	.029
A PARAM C2	NA	.021	.021	.033	.047	.058	.060

CORPUS CHRISTI, TEXAS — LATITUDE = 27.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	2074.7	775.63	351.59	188.98	114.52	78.14	56.95
VT2/DD	1765.6	660.09	299.21	160.83	97.46	66.50	48.47
VT3/DD	1533.1	573.14	259.80	139.64	84.62	57.74	42.08
ANNUAL DD	28	81	185	364	648	1065	1647
PARAMETER A	.325	.401	.523	.573	.591	.553	.522
OFF SOUTH							
VTN/DD B1	-.542	-.542	-.542	-.542	-.542	-.542	-.542
VTN/DD B2	-.098	-.098	-.098	-.098	-.098	-.098	-.098
A PARAM C1	1.746	1.316	.904	.760	.677	.681	.666
A PARAM C2	.034	.037	.035	.041	.049	.063	.079

DEL RIO, TEXAS — LATITUDE = 29.2

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	976.52	463.19	249.37	147.39	96.63	68.92	52.23
VT2/DD	823.24	390.48	210.23	124.26	81.47	58.11	44.03
VT3/DD	712.82	338.11	182.03	107.59	70.54	50.31	38.13
ANNUAL DD	66	168	364	672	1095	1656	2402
PARAMETER A	.452	.486	.430	.450	.479	.502	.526
OFF SOUTH							
VTN/DD B1	-1.264	-1.264	-1.264	-1.264	-1.264	-1.264	-1.264
VTN/DD B2	-.069	-.069	-.069	-.069	-.069	-.069	-.069
A PARAM C1	1.851	1.618	1.812	1.681	1.553	1.468	1.394
A PARAM C2	-.072	-.075	-.089	-.083	-.071	-.056	-.038

EL PASO, TEXAS — LATITUDE = 31.8

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	431.50	247.38	158.85	109.62	80.66	62.30	50.41
VT2/DD	368.00	210.98	135.47	93.49	68.79	53.13	42.99
VT3/DD	319.65	183.25	117.67	81.20	59.75	46.15	37.34
ANNUAL DD	222	458	825	1334	2001	2826	3808
PARAMETER A	.551	.582	.560	.558	.545	.532	.520
OFF SOUTH							
VTN/DD B1	-.165	-.165	-.165	-.165	-.165	-.165	-.165
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	.245	.365	.557	.699	.844	.978	1.118
A PARAM C2	.007	.015	.025	.035	.047	.063	.083

FORT WORTH, TEXAS — LATITUDE = 32.8

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	280.94	163.65	103.78	71.97	53.08	41.24	33.52
VT2/DD	239.55	139.54	88.49	61.37	45.26	35.17	28.58
VT3/DD	208.03	121.18	76.85	53.29	39.31	30.54	24.82
ANNUAL DD	229	449	793	1257	1870	2643	3598
PARAMETER A	.603	.594	.593	.597	.610	.615	.612
OFF SOUTH							
VTN/DD B1	-.392	-.392	-.392	-.392	-.392	-.392	-.392
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	.228	.262	.265	.257	.237	.222	.212
A PARAM C2	.025	.028	.031	.036	.041	.049	.064

HOUSTON, TEXAS — LATITUDE = 29.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	718.24	353.23	190.70	112.19	74.71	53.36	40.44
VT2/DD	611.12	300.55	162.26	95.46	63.57	45.40	34.41
VT3/DD	530.48	260.89	140.85	82.86	55.18	39.41	29.87
ANNUAL DD	52	146	314	589	1001	1580	2349
PARAMETER A	.646	.453	.404	.474	.519	.556	.564
OFF SOUTH							
VTN/DD B1	-.689	-.689	-.689	-.689	-.689	-.689	-.689
VTN/DD B2	-.094	-.094	-.094	-.094	-.094	-.094	-.094
A PARAM C1	.608	1.428	1.709	1.423	1.270	1.152	1.103
A PARAM C2	.020	.044	.056	.052	.057	.064	.075

KINGSVILLE, TEXAS — LATITUDE = 27.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	1126.3	412.97	207.39	121.11	80.12	57.07
VT2/DD	NA	955.39	350.29	175.92	102.73	67.96	48.41
VT3/DD	NA	829.06	303.97	152.65	89.14	58.97	42.01
ANNUAL DD	NA	53	158	351	649	1066	1649
PARAMETER A	NA	.621	.695	.643	.609	.578	.562
OFF SOUTH							
VTN/DD B1	NA	-.980	-.980	-.980	-.980	-.980	-.980
VTN/DD B2	NA	-.084	-.084	-.084	-.084	-.084	-.084
A PARAM C1	NA	1.611	1.390	1.606	1.776	1.921	1.997
A PARAM C2	NA	.005	.014	.023	.028	.033	.039

LAREDO, TEXAS — LATITUDE = 27.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	NA	1580.5	597.22	281.12	154.40	96.00	66.69
VT2/DD	NA	1345.2	508.33	239.28	131.05	81.48	56.61
VT3/DD	NA	1168.2	441.43	207.79	113.74	70.72	49.13
ANNUAL DD	NA	45	144	339	643	1082	1676
PARAMETER A	NA	.393	.391	.371	.382	.410	.433
OFF SOUTH							
VTN/DD B1	NA	-1.272	-1.272	-1.272	-.119	-.119	-.119
VTN/DD B2	NA	-.097	-.097	-.097	-.089	-.089	-.089
A PARAM C1	NA	1.759	2.173	2.703	-2.682	-2.371	-2.193
A PARAM C2	NA	.030	.045	.061	.022	.034	.046

LUBBOCK, TEXAS — LATITUDE = 33.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	198.69	124.76	87.90	66.86	53.32	44.19	37.70
VT2/DD	169.73	106.57	75.09	57.12	45.55	37.75	32.20
VT3/DD	147.48	92.60	65.24	49.63	39.57	32.80	27.98
ANNUAL DD	608	1026	1568	2242	3055	4000	5125
PARAMETER A	.480	.517	.540	.544	.540	.530	.520
OFF SOUTH							
VTN/DD B1	.369	.369	.369	.369	.369	.369	.369
VTN/DD B2	-.111	-.111	-.111	-.111	-.111	-.111	-.111
A PARAM C1	-1.170	-1.090	-1.070	-1.080	-1.093	-1.112	-1.137
A PARAM C2	.055	.055	.057	.064	.076	.091	.112

LUFKIN, TEXAS — LATITUDE = 31.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	372.79	201.06	128.05	87.27	63.88	49.33	39.17
VT2/DD	317.07	171.01	108.91	74.22	54.33	41.95	33.31
VT3/DD	275.22	148.44	94.54	64.43	47.16	36.42	28.92
ANNUAL DD	166	329	580	952	1457	2095	2929
PARAMETER A	.527	.594	.600	.583	.543	.524	.530
OFF SOUTH							
VTN/DD B1	-.746	-.746	-.746	-.746	-.746	-.746	-.746
VTN/DD B2	-.092	-.092	-.092	-.092	-.092	-.092	-.092
A PARAM C1	-.459	-.306	-.165	-.042	.062	.152	.222
A PARAM C2	.001	.006	.016	.027	.037	.047	.060

MIDLAND-ODESSA, TEXAS LATITUDE = 31.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	415.04	212.73	131.11	90.69	68.06	53.88	44.46
VT2/DD	354.13	181.51	111.87	77.38	58.07	45.98	37.94
VT3/DD	307.65	157.69	97.19	67.23	50.45	39.94	32.96
ANNUAL DD	255	542	953	1491	2148	2953	3935
PARAMETER A	.510	.565	.577	.568	.559	.554	.557
OFF SOUTH							
VTN/DD B1	.504	.504	.504	.504	.504	.504	.504
VTN/DD B2	-.107	-.107	-.107	-.107	-.107	-.107	-.107
A PARAM C1	-1.322	-1.258	-1.310	-1.404	-1.496	-1.575	-1.636
A PARAM C2	.027	.031	.036	.046	.057	.069	.084

PORT ARTHUR, TEXAS LATITUDE = 29.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	1322.8	529.37	268.89	146.63	86.41	57.57	41.57
VT2/DD	1127.1	451.08	229.12	124.54	73.40	48.89	35.31
VT3/DD	978.80	391.70	198.96	108.08	63.70	42.43	30.64
ANNUAL DD	44	129	300	595	1025	1628	2439
PARAMETER A	.545	.455	.350	.366	.470	.536	.578
OFF SOUTH							
VTN/DD B1	-.346	-.346	-.346	-.829	-.829	-.829	-.829
VTN/DD B2	-.101	-.101	-.101	-.089	-.089	-.089	-.089
A PARAM C1	.011	-.147	-.057	2.358	1.884	1.710	1.634
A PARAM C2	.052	.067	.096	.031	.029	.035	.045

SAN ANGELO, TEXAS LATITUDE = 31.2

DUE SOUTH	TR40 (M=12)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	442.92	245.39	148.57	98.36	71.09	54.60	43.98
VT2/DD	378.36	209.16	126.64	83.84	60.59	46.54	37.48
VT3/DD	328.74	181.66	109.99	72.82	52.63	40.42	32.56
ANNUAL DD	240	464	784	1229	1800	2512	3387
PARAMETER A	.363	.382	.443	.473	.486	.493	.503
OFF SOUTH							
VTN/DD B1	.222	-.195	-.195	-.195	-.195	-.195	-.195
VTN/DD B2	-.110	-.101	-.101	-.101	-.101	-.101	-.101
A PARAM C1	-1.757	.316	.253	.231	.208	.166	.110
A PARAM C2	.082	.044	.048	.053	.062	.071	.084

SAN ANTONIO, TEXAS LATITUDE = 29.3

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	686.93	341.56	198.18	124.56	85.52	63.13	48.81
VT2/DD	585.26	291.01	168.85	106.13	72.86	53.79	41.58
VT3/DD	508.25	252.72	146.63	92.16	63.28	46.71	36.11
ANNUAL DD	78	200	425	771	1242	1844	2609
PARAMETER A	.692	.695	.570	.494	.470	.459	.451
OFF SOUTH							
VTN/DD B1	-1.157	-1.157	-1.157	-1.157	-1.157	-1.157	-1.157
VTN/DD B2	-.099	-.099	-.099	-.099	-.099	-.099	-.099
A PARAM C1	.653	.861	1.255	1.529	1.625	1.672	1.703
A PARAM C2	.008	.022	.042	.057	.070	.085	.104

SHERMAN, TEXAS LATITUDE = 33.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	249.95	137.53	87.51	61.86	47.15	37.77	31.22
VT2/DD	213.25	117.33	74.66	52.78	40.23	32.22	26.64
VT3/DD	185.20	101.90	64.84	45.84	34.94	27.98	23.13
ANNUAL DD	222	477	872	140[illegible]	2091	2920	3902
PARAMETER A	.727	.693	.648	.598	.570	.549	.538
OFF SOUTH							
VTN/DD B1	.528	.528	.528	.528	.528	.528	.528
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	-.632	-.893	-1.123	-1.314	-1.439	-1.552	-1.650
A PARAM C2	.025	.032	.039	.046	.053	.063	.078

WACO, TEXAS — LATITUDE = 31.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	325.18	185.94	118.18	79.89	57.64	43.87	35.12
VT2/DD	276.73	158.24	100.58	67.99	49.05	37.33	29.89
VT3/DD	240.25	137.38	87.32	59.03	42.58	32.41	25.95
ANNUAL DD	196	399	714	1157	1729	2443	3300
PARAMETER A	.664	.610	.551	.552	.556	.570	.572
OFF SOUTH							
VTN/DD B1	-.835	-.835	-.835	-.835	-.835	-.835	-.835
VTN/DD B2	-.093	-.093	-.093	-.093	-.093	-.093	-.093
A PARAM C1	.939	1.063	1.215	1.220	1.208	1.166	1.145
A PARAM C2	.022	.024	.028	.031	.035	.040	.048

WICHITA FALLS, TEXAS — LATITUDE = 33.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	204.85	124.75	85.28	63.12	49.15	39.78	33.20
VT2/DD	174.72	106.40	72.74	53.84	41.92	33.93	28.32
VT3/DD	151.74	92.41	63.17	46.76	36.41	29.47	24.59
ANNUAL DD	463	786	1225	1793	2508	3378	4402
PARAMETER A	.410	.445	.459	.455	.477	.501	.515
OFF SOUTH							
VTN/DD B1	-.055	-.055	-.055	-.055	-.055	-.055	-.055
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	.232	.179	.148	.124	.101	.076	.049
A PARAM C2	.040	.043	.047	.053	.058	.067	.081

BRYCE CANYON, UTAH — LATITUDE = 37.4

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	68.05	54.50	45.36	38.84	33.95	30.16	27.13
VT2/DD	58.30	46.69	38.86	33.27	29.09	25.84	23.24
VT3/DD	50.67	40.58	33.78	28.92	25.28	22.46	20.20
ANNUAL DD	2929	3969	5147	6450	7884	9431	11088
PARAMETER A	.492	.473	.452	.426	.394	.354	.307
OFF SOUTH							
VTN/DD B1	.048	.048	.048	.048	.048	.048	.048
VTN/DD B2	-.120	-.120	-.120	-.120	-.120	-.120	-.120
A PARAM C1	.712	.797	.883	.988	1.135	1.345	1.655
A PARAM C2	.123	.151	.181	.218	.266	.333	.427

CEDAR CITY, UTAH — LATITUDE = 37.4

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	102.65	73.60	56.04	44.86	37.38	32.03	28.02
VT2/DD	88.00	63.09	48.04	38.46	32.04	27.46	24.02
VT3/DD	76.50	54.84	41.76	33.43	27.85	23.87	20.88
ANNUAL DD	1364	2055	2890	3865	4984	6258	7679
PARAMETER A	.505	.516	.521	.520	.517	.517	.515
OFF SOUTH							
VTN/DD B1	.447	.447	.447	.447	.447	.447	.447
VTN/DD B2	-.122	-.122	-.122	-.122	-.122	-.122	-.122
A PARAM C1	-1.109	-1.029	-.980	-.957	-.949	-.933	-.923
A PARAM C2	.091	.102	.116	.133	.151	.167	.187

SALT LAKE CITY, UTAH — LATITUDE = 40.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	59.92	44.05	34.47	28.24	23.91	20.73	18.30
VT2/DD	51.27	37.69	29.50	24.16	20.46	17.74	15.65
VT3/DD	44.54	32.74	25.62	20.99	17.77	15.41	13.60
ANNUAL DD	1263	1957	2812	3814	4969	6251	7646
PARAMETER A	.731	.775	.804	.822	.833	.837	.835
OFF SOUTH							
VTN/DD B1	-.020	-.020	-.020	-.020	-.020	-.020	-.020
VTN/DD B2	-.112	-.112	-.112	-.112	-.112	-.112	-.112
A PARAM C1	-.067	-.050	-.037	-.025	-.012	-.000	.011
A PARAM C2	.002	.010	.018	.027	.037	.047	.057

BURLINGTON, VERMONT — LATITUDE = 44.3

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	24.84	19.88	16.35	13.84	11.93	10.45	9.30
VT2/DD	21.25	17.01	13.99	11.84	10.21	8.94	7.95
VT3/DD	18.46	14.77	12.15	10.29	8.87	7.77	6.91
ANNUAL DD	2430	3260	4214	5310	6552	7945	9483
PARAMETER A	.563	.620	.677	.734	.789	.838	.880
OFF SOUTH							
VTN/DD B1	-.042	-.184	-.184	-.184	-.184	-.184	-.184
VTN/DD B2	-.110	-.109	-.109	-.109	-.109	-.109	-.109
A PARAM C1	.136	.590	.589	.578	.563	.547	.532
A PARAM C2	.055	.053	.052	.052	.052	.052	.054

NORFOLK, VIRGINIA — LATITUDE = 36.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	172.33	104.69	62.77	42.85	32.41	26.07	21.80
VT2/DD	147.25	89.45	53.13	36.27	27.44	22.06	18.45
VT3/DD	127.90	77.70	46.05	31.43	23.78	19.12	15.99
ANNUAL DD	368	764	1302	1971	2778	3736	4875
PARAMETER A	.509	.346	.463	.571	.637	.670	.694
OFF SOUTH							
VTN/DD B1	-.460	-.460	.990	.990	.990	.990	.990
VTN/DD B2	-.110	-.110	-.073	-.073	-.073	-.073	-.073
A PARAM C1	1.600	2.917	-3.033	-2.389	-2.124	-2.033	-1.977
A PARAM C2	.045	.090	-.071	-.051	-.040	-.031	-.022

RICHMOND, VIRGINIA — LATITUDE = 37.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	114.44	72.05	50.92	38.65	30.99	25.80	22.05
VT2/DD	97.70	61.51	43.47	32.99	26.46	22.02	18.83
VT3/DD	84.84	53.42	37.75	28.65	22.98	19.13	16.35
ANNUAL DD	595	1023	1587	2299	3154	4165	5354
PARAMETER A	.534	.603	.623	.622	.613	.610	.613
OFF SOUTH							
VTN/DD B1	-.299	-.299	-.299	-.299	-.299	-.299	-.299
VTN/DD B2	-.105	-.105	-.105	-.105	-.105	-.105	-.105
A PARAM C1	1.582	1.359	1.291	1.268	1.256	1.221	1.166
A PARAM C2	.032	.032	.036	.043	.051	.059	.070

ROANOKE, VIRGINIA — LATITUDE = 37.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	111.01	69.69	49.08	37.46	30.12	25.07	21.44
VT2/DD	94.67	59.43	41.85	31.94	25.68	21.38	18.28
VT3/DD	82.19	51.60	36.34	27.74	22.30	18.56	15.87
ANNUAL DD	662	1118	1722	2484	3387	4451	5708
PARAMETER A	.556	.603	.617	.623	.621	.626	.640
OFF SOUTH							
VTN/DD B1	.382	.382	.382	.382	.382	.382	.382
VTN/DD B2	-.099	-.099	-.099	-.099	-.099	-.099	-.099
A PARAM C1	-.949	-.976	-1.042	-1.116	-1.207	-1.270	-1.298
A PARAM C2	.024	.025	.029	.034	.041	.048	.056

OLYMPIA, WASHINGTON — LATITUDE = 46.6

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	82.21	37.47	21.07	14.33	10.86	8.74	7.31
VT2/DD	70.08	31.91	17.94	12.21	9.25	7.44	6.23
VT3/DD	60.82	27.69	15.57	10.59	8.02	6.46	5.40
ANNUAL DD	416	939	1793	2929	4301	5851	7507
PARAMETER A	.869	.970	1.083	1.152	1.208	1.247	1.270
OFF SOUTH							
VTN/DD B1	.359	.162	.162	.162	.162	.162	.162
VTN/DD B2	-.094	-.089	-.089	-.089	-.089	-.089	-.089
A PARAM C1	-.307	-.028	-.061	-.091	-.119	-.147	-.173
A PARAM C2	.015	.008	.009	.011	.013	.015	.018

SEATTLE, WASHINGTON LATITUDE = 47.4

DUE SOUTH	TR40 (M=12)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	81.35	40.92	24 10	15.96	11.91	9.50	7.90
VT2/DD	69.47	34.83	20.51	13.63	10 17	8.11	6.74
VT3/DD	60.32	30.22	17.80	11.83	8.83	7.04	5.86
ANNUAL DD	284	732	1500	2585	3957	5531	7223
PARAMETER A	.782	.890	.954	1.039	1.121	1.179	1.212
OFF SOUTH							
VTN/DD B1	.324	.460	.460	.324	.324	.324	.324
VTN/DD B2	-.099	-.086	-.086	-.099	-.099	-.099	-.099
A PARAM C1	-.320	-.568	-.565	-.343	-.319	-.317	-.331
A PARAM C2	.024	.003	.007	.029	.029	.030	.032

SPOKANE, WASHINGTON LATITUDE = 47.4

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	24.35	17.29	13.38	10.91	9.21	7.97	7.02
VT2/DD	20.81	14.78	11.43	9.32	7.87	6.81	6.00
VT3/DD	18.08	12.83	9.93	8.10	6.84	5.92	5.21
ANNUAL DD	1338	2135	3113	4247	5540	6982	8536
PARAMETER A	.983	1.048	1.107	1.158	1.209	1.255	1.290
OFF SOUTH							
VTN/DD B1	.317	.317	.317	.317	.317	.317	.317
VTN/DD B2	-.104	-.104	-.104	-.104	-.104	-.104	-.104
A PARAM C1	.063	.034	.021	.017	.015	.014	.013
A PARAM C2	.006	.007	.009	.011	.012	.014	.016

WHIDBEY ISLAND, WASHINGTON LATITUDE = 48.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	96 96	42.80	25.13	17.33	12.98	9.59	7.60
VT2/DD	82.61	36.47	21.42	14.77	11.03	8.14	6.45
VT3/DD	71.69	31.64	18.58	12.82	9.57	7.06	5.60
ANNUAL DD	221	557	1231	2296	3739	5424	7203
PARAMETER A	1.099	1.152	1.123	1.116	1.170	1.289	1.350
OFF SOUTH							
VTN/DD B1	.238	.238	.238	.238	.962	.962	.962
VTN/DD B2	-.090	-.090	-.090	-.090	-.077	-.077	-.077
A PARAM C1	-.260	-.210	-.270	-.326	-1.161	-1.025	-.973
A PARAM C2	.003	.005	.008	.013	.001	.004	.007

YAKIMA, WASHINGTON LATITUDE = 46.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	30.46	22.45	17.46	14.20	11.95	10.31	9.07
VT2/DD	26.02	19.17	14.91	12.13	10.20	8.81	7.74
VT3/DD	22.59	16.65	12.95	10.53	8.86	7.65	6.72
ANNUAL DD	1070	1737	2601	3657	4863	6219	7699
PARAMETER A	.886	.952	1.011	1.059	1.098	1.134	1.162
OFF SOUTH							
VTN/DD B1	-.009	-.009	-.009	-.009	-.009	-.009	-.009
VTN/DD B2	-.102	-.102	-.102	-.102	-.102	-.102	-.102
A PARAM C1	-.114	-.047	.005	.045	.074	.096	.113
A PARAM C2	-.001	.001	.004	.007	.009	.012	.015

CHARLESTON, WEST VIRGINIA LATITUDE = 38.2

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	53.22	39.44	30.41	24.15	19.52	15.86	13.31
VT2/DD	45.34	33.61	25.91	20.58	16.62	13.51	11.33
VT3/DD	39.36	29.17	22.49	17.86	14.43	11.72	9.84
ANNUAL DD	907	1406	2034	2822	3768	4875	6159
PARAMETER A	.570	.575	.575	.592	.630	.698	.759
OFF SOUTH							
VTN/DD B1	-.016	-.016	-.016	-.016	-.116	-.116	-.116
VTN/DD B2	-.095	-.095	-.095	-.095	-.091	-.091	-.091
A PARAM C1	-.136	-.202	-.259	-.301	-.070	-.092	-.105
A PARAM C2	.031	.038	.045	.050	.043	.043	.045

EAU CLAIRE, WISCONSIN LATITUDE = 44.5

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	18.24	14.75	12.37	10.64	9.34	8.32	7.50
VT2/DD	15.59	12.61	10.57	9.10	7.98	7.11	6.41
VT3/DD	13.54	10.95	9.18	7.90	6.93	6.17	5.57
ANNUAL DD	2982	3847	4813	5883	7068	8390	9858
PARAMETER A	.734	.806	.870	.925	.975	1.022	1.064
OFF SOUTH							
VTN/DD B1	.157	.157	.157	.157	.157	.157	.157
VTN/DD B2	-.106	-.106	-.106	-.106	-.106	-.106	-.106
A PARAM C1	.044	.119	.161	.185	.196	.198	.197
A PARAM C2	.013	.014	.016	.017	.019	.020	.022

GREEN BAY, WISCONSIN LATITUDE = 44.3

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	24.59	20.50	17.10	14.59	12.71	11.26	10.11
VT2/DD	21.07	17.57	14.65	12.50	10.89	9.65	8.66
VT3/DD	18.30	15.26	12.73	10.86	9.46	8.38	7.52
ANNUAL DD	2564	3420	4394	5502	6757	8145	9677
PARAMETER A	.623	.641	.697	.754	.805	.846	.879
OFF SOUTH							
VTN/DD B1	-.145	-.145	1.139	1.139	1.139	1.139	1.139
VTN/DD B2	-.116	-.116	-.114	-.114	-.114	-.114	-.114
A PARAM C1	1.593	1.553	-1.848	-1.680	-1.555	-1.468	-1.405
A PARAM C2	.036	.042	.040	.042	.044	.047	.051

LA CROSSE, WISCONSIN LATITUDE = 43.5

DUE SOUTH	TR40 (M= 1)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	30.83	23.77	19.04	15.88	13.62	11.92	10.60
VT2/DD	26.41	20.35	16.30	13.59	11.63	10.21	9.07
VT3/DD	22.94	17.68	14.16	11.81	10.13	8.87	7.88
ANNUAL DD	2236	3036	3938	4959	6117	7416	8859
PARAMETER A	.505	.559	.629	.693	.751	.800	.843
OFF SOUTH							
VTN/DD B1	-.773	-.275	-.275	-.275	-.275	-.275	-.275
VTN/DD B2	-.116	-.113	-.113	-.113	-.113	-.113	-.113
A PARAM C1	1.324	-.360	-.220	-.131	-.070	-.025	.011
A PARAM C2	.055	.042	.041	.041	.042	.045	.047

MADISON, WISCONSIN LATITUDE = 43.1

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	29.88	24.62	20.38	16.95	14.50	12.68	11.26
VT2/DD	25.57	21.07	17.46	14.52	12.43	10.86	9.65
VT3/DD	22.21	18.30	15.17	12.62	10.80	9.44	8.38
ANNUAL DD	2359	3168	4074	5103	6261	7567	9029
PARAMETER A	.588	.567	.596	.663	.720	.771	.815
OFF SOUTH							
VTN/DD B1	-.413	-.413	.159	.159	.159	.159	.159
VTN/DD B2	-.112	-.112	-.119	-.119	-.119	-.119	-.119
A PARAM C1	.958	1.068	-.709	-.594	-.511	-.446	-.394
A PARAM C2	.040	.047	.071	.067	.065	.066	.067

MILWAUKEE, WISCONSIN LATITUDE = 42.6

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	32.05	24.47	19.69	16.44	14.10	12.33	10.95
VT2/DD	27.42	20.94	16.84	14.07	12.06	10.55	9.37
VT3/DD	23.82	18.19	14.63	12.22	10.48	9.16	8.14
ANNUAL DD	1891	2693	3623	4673	5865	7212	8708
PARAMETER A	.597	.654	.708	.753	.793	.833	.866
OFF SOUTH							
VTN/DD B1	.312	.312	.312	.312	.312	.312	.312
VTN/DD B2	-.110	-.110	-.110	-.110	-.110	-.110	-.110
A PARAM C1	.091	.044	.008	-.018	-.038	-.056	-.072
A PARAM C2	.042	.045	.048	.050	.053	.055	.059

CASPER, WYOMING LATITUDE = 42.6

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	68.92	52.86	42.11	34.52	29.22	25.30	22.31
VT2/DD	59.13	45.35	36.16	29.64	25.09	21.73	19.16
VT3/DD	51.41	39.43	31.44	25.77	21.82	18.89	16.66
ANNUAL DD	2112	3003	4046	5212	6496	7892	9404
PARAMETER A	.559	.540	.536	.549	.555	.560	.560
OFF SOUTH							
VTN/DD B1	-.159	-.159	.518	.518	.518	.518	.518
VTN/DD B2	-.123	-.123	-.127	-.127	-.127	-.127	-.127
A PARAM C1	.620	.640	-1.812	-1.760	-1.727	-1.698	-1.678
A PARAM C2	.089	.102	.129	.138	.149	.161	.174

CHEYENNE, WYOMING LATITUDE = 41.1

DUE SOUTH	TR40 (M= 2)	TR45 (M= 2)	TR50 (M= 2)	TR55 (M= 2)	TR60 (M= 2)	TR65 (M= 2)	TR70 (M= 2)
VT1/DD	78.65	59.68	47.62	39.43	33.62	29.31	25.97
VT2/DD	66.83	50.71	40.47	33.51	28.57	24.91	22.07
VT3/DD	57.96	43.98	35.09	29.06	24.78	21.60	19.14
ANNUAL DD	1859	2684	3678	4821	6120	7573	9141
PARAMETER A	.535	.525	.510	.496	.483	.472	.451
OFF SOUTH							
VTN/DD B1	-.098	-.098	-.098	-.098	-.098	-.098	-.098
VTN/DD B2	-.086	-.088	-.088	-.088	-.088	-.088	-.088
A PARAM C1	-.332	-.237	-.118	.019	.166	.317	.487
A PARAM C2	-.028	-.013	.002	.019	.037	.057	.082

ROCK SPRINGS, WYOMING LATITUDE = 41.4

DUE SOUTH	TR40 (M=12)	TR45 (M=12)	TR50 (M=12)	TR55 (M=12)	TR60 (M=12)	TR65 (M=12)	TR70 (M=12)
VT1/DD	64.32	50.35	41.31	35.02	30.39	26.85	24.04
VT2/DD	55.26	43.26	35.49	30.09	26.11	23.07	20.65
VT3/DD	48.05	37.61	30.86	26.10	22.71	20.06	17.96
ANNUAL DD	2546	3528	4645	5882	7245	8729	10317
PARAMETER A	.445	.463	.472	.472	.470	.464	.450
OFF SOUTH							
VTN/DD B1	.111	.111	.111	.111	.111	.111	.111
VTN/DD B2	-.129	-.129	-.129	-.129	-.129	-.129	-.129
A PARAM C1	.611	.589	.587	.599	.615	.640	.680
A PARAM C2	.124	.137	.153	.173	.194	.217	.247

SHERIDAN, WYOMING LATITUDE = 44.5

DUE SOUTH	TR40 (M= 1)	TR45 (M= 1)	TR50 (M= 1)	TR55 (M= 1)	TR60 (M= 1)	TR65 (M= 1)	TR70 (M= 1)
VT1/DD	37.65	30.41	25.37	21.74	19.02	16.90	15.21
VT2/DD	32.27	26.07	21.75	18.64	16.30	14.49	13.04
VT3/DD	28.05	22.66	18.90	16.20	14.17	12.59	11.33
ANNUAL DD	2051	2883	3858	4990	6277	7709	9256
PARAMETER A	.809	.786	.768	.761	.758	.756	.748
OFF SOUTH							
VTN/DD B1	-.001	-.001	-.001	-.001	-.001	-.001	-.001
VTN/DD B2	-.118	-.118	-.118	-.118	-.118	-.118	-.118
A PARAM C1	.106	.131	.155	.171	.179	.184	.192
A PARAM C2	.026	.034	.043	.052	.061	.070	.081

DATE
ILME

	1R40	1R45	[illegible]	[illegible]			
DUE SOUTH	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)	(M= 1)
VT1/DD	280.94	163.65	103.78	71.97	53.08	41.24	33.52
VT2/DD	239.55	139.54	88.49	61.37	45.26	35.17	28.58
VT3/DD	208.03	121.18	76.85	53.29	39.31	30.54	24.82
ANNUAL DD	229	449	793	1257	1870	2643	3598
PARAME ER A	.603	.594	.593	.597	.610	.615	.612
OFF SOUTH							
VTN/DD B1	-.392	-.392	-.392	-.392	-.392	-.392	-.392
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	.228	.262	.265	.257	.237	.222	.212
A PARAM C2	.025	.028	.031	.036	.041	.049	.064

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VT2/DD	317.07	171.01	108.91	74.22	54.33	41.95	33.31
VT3/DD	275.22	148.44	94.54	64.43	47.16	36.42	28.92
ANNUAL DD	166	329	580	952	1457	2095	2929
PARAMETER A	.527	.594	.600	.583	.543	.524	.530
OFF SOUTH							
VTN/DD B1	-.746	-.746	-.746	-.746	-.746	-.746	-.746
VTN/DD B2	-.092	-.092	-.092	-.092	-.092	-.092	-.092
A PARAM C1	-.459	-.306	-.165	-.042	.062	.152	.222
A PARAM C2	.001	.006	.016	.027	.037	.047	.060

[illegible]	[illegible]	[illegible]	[illegible]				
VT2/DD	213.25	117.33	74.66	52.78	40.23	32.22	[illegible]
VT3/DD	185.20	101.90	64.84	45.84	34.94	27.98	23.13
ANNUAL DD	222	477	872	1407	2091	2920	3902
PARAMETER A	.727	.693	.648	.598	.570	.549	.538
OFF SOUTH							
VTN/DD B1	.528	.528	.528	.528	.528	.526	.528
VTN/DD B2	-.103	-.103	-.103	-.103	-.103	-.103	-.103
A PARAM C1	-.632	-.893	-1.123	-1.314	-1.439	-1.552	-1.650
A PARAM C2	.025	.032	.039	.046	.053	.063	.078